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PAVEMENTS FOR CITY STREETS.

THE street commissioner of St. Louis has issued a very instructive pamphlet illustrated by half-tone engravings, showing the condition of the streets of that city and the methods adopted for paving it. This pamphlet is accompanied with excellent sectional views, showing the method of construction adopted in laying the various forms of pavement. These sections are particularly instructive, as St. Louis includes not only streets where traffic is heavy, but avenues, boulevards, and park roads where the travel is mostly light. By kind permission of the street commissioner, Mr. Abram M. Milner, we are enabled to present these sectional views. The report contains admirable specifications which are worthy of adoption by other cities, and though the estimated cost of materials and labor is based on the local price in St. Louis, still the figures are very valuable in estimating in other places.

The cost of street construction is estimated to be as follows:

STREET CONSTRUCTION.

Estimated cost of materials used in street construction:

Street complete, paved with granite	$30.00 per square.
Street complete, paved with brick	18.00 " "
Street complete, paved with rock asphaltum	$25.00 per square.
Street complete, paved with Trinidad L asphaltum	30.00 " "
Street complete, paved with Telford	10.00 " "

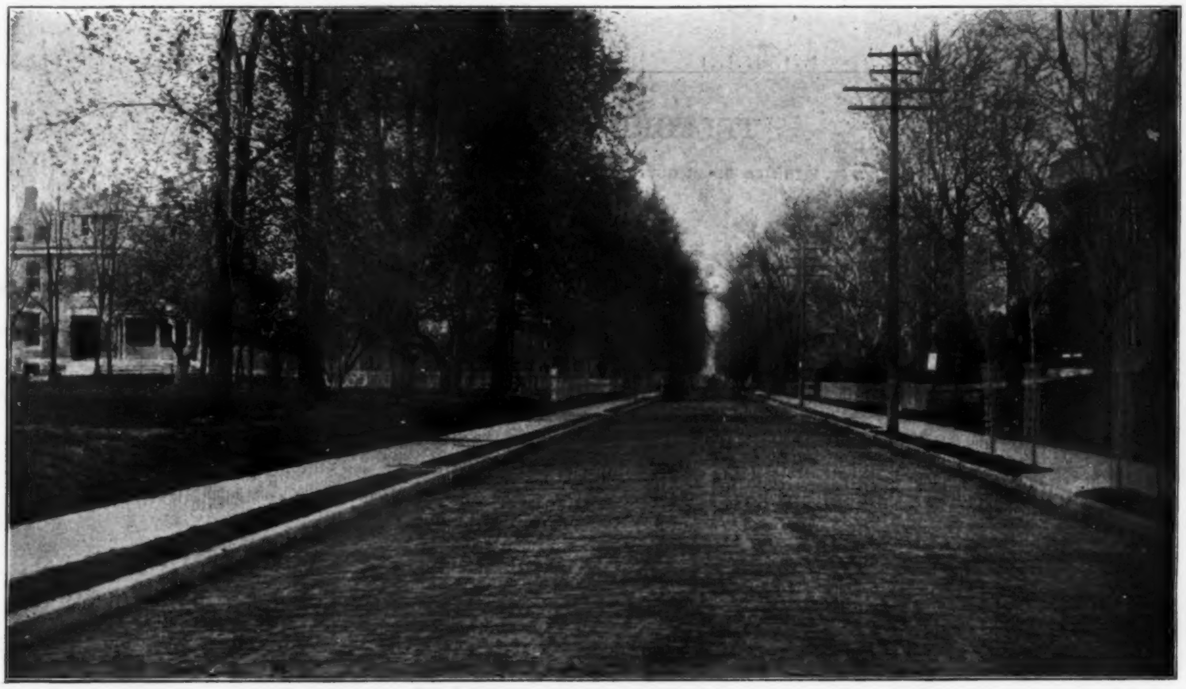
Cost of street paving material:

Preparing roadway	$0.30 per cubic yard.
Telford	4.00 " square.
Macadam	4.00 " square.
Concrete, 6 in. deep	$7.00 per square.
Cinders	2.00 " "
Sand	2.00 " "
Gravel	7.00 " "
Curbing, 6 in. granite, 16 in. deep	1.00 " linear foot.
Curbing, 8 in. oolitic, 16 in. deep	.80 " " "
Combination curb and gutter	$0.90 per linear foot.
Rolling	8.25 " day.
Vitrified brick	11.00 " square.
Granite blocks	25.00 " "
Asphaltum, complete	30.00 " "

Curb stones not to be less than 4 ft. 6 in. long.

Size of granite blocks:

Not less than 9 in. nor more than 12 in. long.
" " " 3½ " " " " 4½ " wide.
" " " 7½ " " " " 8½ " deep.



BRICK PAVEMENT WITH STONE CURB.

TELFORD PAVEMENT WITH CONCRETE GUTTERS.

Size of vitrified brick:

Not less than	8	in. nor more than	9	in. long.
" " "	2½	" " " "	4	" wide.
" " "	4	" " " "	4½	" deep.

Size of vitrified blocks:

Not less than	9	in. nor more than	12	in. long.
" " "	3½	" " " "	4½	" wide.
" " "	5	" " " "	6	" deep.

Cost of granitoid sidewalk:

Single thick, 8 in. cinders, 3½ in. lower course concrete, ½ in. wearing surface........ 14½ cents per square foot.

Cost of a 60 ft. street, 36 ft. roadway, improved with:

Granite	$8.00	per front ft.
Brick	4.50	" " "
Asphaltum	7.00	" " "
Telford	2.75	" " "

Alleys:

15 ft. granite alley	$2.25	per front ft.
20 " " "	3.00	" " "
15 " brick "	1.40	" " "
20 " " "	1.75	" " "
15 " limestone "	1.00	" " "
20 " " "	1.30	" " "

and of such length as may be directed by the street commissioner.

COLORING.

The wearing surface of the sidewalk pavement, when required, shall be mixed with such color or colors as the street commissioner may direct.

PREPARING THE BED FOR THE SIDEWALK PAVEMENT.

The sidewalks shall be excavated and shaped to the proper depth and grade as directed by the street commissioner, and all the refuse material therefrom shall belong to the contractor and shall be promptly removed from the line of work.

ORDINARY SINGLE FLAGGING.

After the shaping is done, a foundation of cinders not less than eight inches thick shall be placed upon the subgrade, which shall be well consolidated by ramming to an even surface, and which shall be moistened just before the concrete is placed thereon.

After the subfoundation has been finished the artificial stone flagging shall be laid in a good, workmanlike manner.

The same to consist of two parts: First—A bottom course, to be three and one-half inches in depth.

Second—A finishing or wearing course, to be one-half inch in depth.

The bottom course shall be composed of crushed granite and Portland cement, which shall be mixed in the proportion of one part of cement and three parts of crushed granite.

The crushed granite shall consist of irregular, sharp edged pieces, so broken that each piece will pass through a three-fourths of an inch ring in all its diameters, and which shall be entirely free from dust or dirt.

The crushed granite and the cement in the above mentioned proportions shall first be mixed dry, then sufficient clean water shall be slowly added by sprinkling while the material is constantly and carefully stirred and worked up, and said stirring and mixing shall be continued until the whole is thoroughly mixed.

This mass shall be spread upon the subfoundation and shall be rammed until all the interstices are thoroughly filled with cement.

Particular care must be taken that the bottom course is well rammed and consolidated along the outer edges.

After the bottom course is completed, the finishing or wearing course shall be added. This course to consist of a stiff mortar, composed of equal parts of Portland cement and the sharp screenings of the crushed granite, free from loamy or earthy substances, and to be laid to a depth of one-half of an inch and to be carefully smoothed to an even surface, which, after the first setting takes place, must not be disturbed by additional rubbing.

When the pavement is completed, it must be covered for three days and be kept moist by sprinkling.

GRANITE STREET CONSTRUCTION.

GRANITE CURBING.

The specifications are as follows: All curbstones shall be of the best quality of granite. The curbing shall have a straight face, fine pean hammer finish on the side toward the roadway for the full depth of the stone, and pitched to line and rough pointed on the side toward the sidewalk, to a depth of six inches from top of curb, and shall have close end joints to the full depth of the stone, and no stone shall be less than four and one-half feet long, nor less than six inches thick, nor less than sixteen inches deep. The curbing shall be set on concrete, six inches deep and twelve inches wide, and backed with concrete six inches wide and ten inches deep, or six inches below top of curbing. The quality of the curb shall be equal in material, dimension and finish to the sample in the street commissioner's office.

Care must be taken not to disturb or break the sidewalk pavement more than necessary, and in all cases, unless otherwise directed, the sidewalk pavement, whenever broken, shall be fully restored.

Whenever the excavation of the roadbed develops too great a width of joint between the old curbing left in position, or openings in the area walls, such joints or openings shall be filled with cement mortar, the mortar being made of one part of cement to one part of sand, or, if necessary, with concrete, as may be determined by the street commissioner.

CONCRETE FOUNDATION.

Upon the roadbed a foundation of hydraulic cement concrete shall be laid to a uniform depth of eight inches. It shall be prepared and applied as herein specified.

SAND.

The sand used in the mortar shall be clean, coarse, screened, Mississippi River channel sand.

CEMENT.

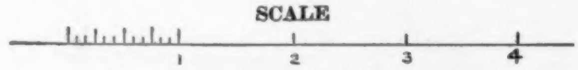
The cement shall be hydraulic cement, equal in all respects to the best Utica or Louisville cement. It shall be newly made, fine ground; ninety per cent. shall pass through a sieve having twenty-five hundred meshes to the square inch, and capable of withstanding a tensile strain of one hundred and fifty pounds per square inch of section when mixed pure, made into briquettes and exposed twenty-four hours in air and six days in water.

All cement shall be in original packages and branded with the name of the manufacturer. Samples for testing shall be furnished in such manner and at such times as may be required. All barrels or packages accepted shall be marked, and the contractor shall carefully preserve these marks and not allow them to be imitated. The cement shall be kept under cover and dry until used, and any cement exposed to the weather after testing shall not be used. Cement may be reinspected at any time when the street commissioner shall so direct, and, if not found to be of proper quality, it shall be rejected. All rejected cement shall be at once removed from the work.

BROKEN STONE OR BROKEN VITRIFIED BRICK.

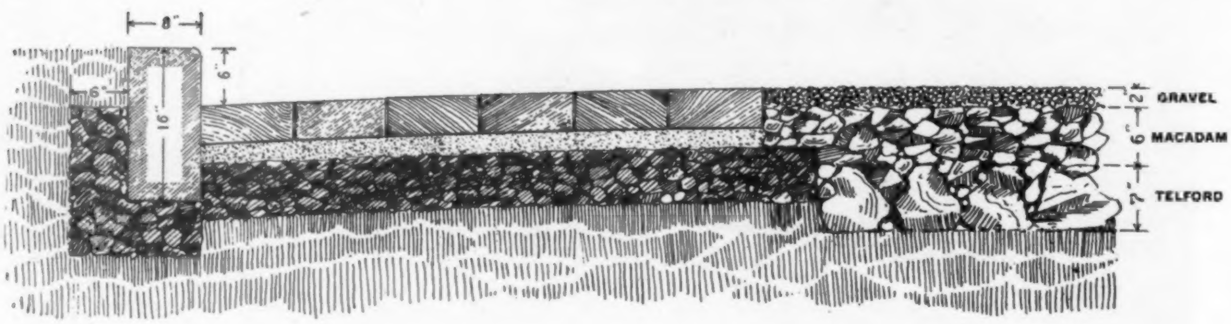
The material for the body of the concrete shall be composed of limestone or vitrified brick, broken so as to pass through a two inch ring in its largest dimensions. The material shall be free from all dust or dirt. Any stone or broken vitrified brick that is dirty or in-

SCALE



TELFORD PAVEMENT.

5 FT. VITRIFIED BRICK GUTTER ON CONCRETE BASE, 6 FT. 6 IN. X 6 IN.



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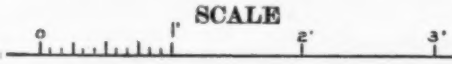
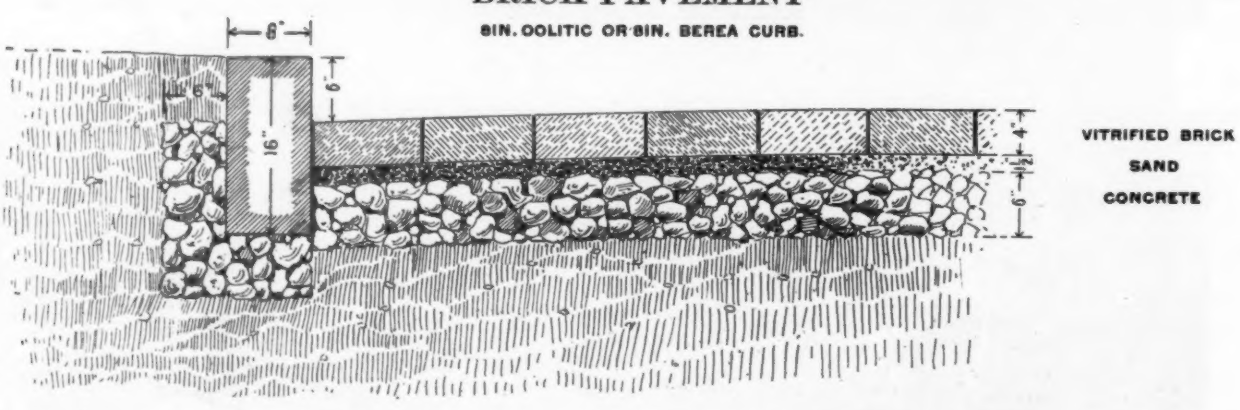


BRICK PAVEMENT

8 IN. OOLITIC OR 8 IN. BEREA CURB.



The specifications for granitoid sidewalk are as follows.

CEMENT.

All cement shall be fine ground. Eighty-five per cent. shall pass through a sieve having ten thousand meshes to the square inch.

All cement shall be capable of withstanding a tensile strain of five hundred pounds per square inch of section, when mixed neat, made into briquettes and exposed twenty-four hours in air and six days under water.

All cement shall be capable of withstanding a tensile strain of two hundred pounds per square inch of section, when mixed in the proportion of three parts sand to one part cement, and exposed twenty-four hours in air and twenty-eight days under water.

All cement shall be put up in well made barrels, and all short weight or damaged barrels will be rejected. Cement without manufacturer's brand and certificate will be rejected without test.

All cement will be subjected to tests for soundness or permanence of volume. All cement for use on the works shall be kept under cover, thoroughly protected from moisture, raised from the ground, by blocking or otherwise, and dry until used. The contractor shall keep in storage a quantity of accepted cement sufficient to insure the uninterrupted progress of the work.

All cement furnished will be subjected to tests of such character as the street commissioner shall determine, and any cement which, in the opinion of the street commissioner, is unsuitable for the work herein specified, will be rejected.

METAL PARTING STRIPS.

The contractor will be required to use metal parting strips, four inches deep, one-fourth of an inch wide

ferior in quality, or not of proper size, will be rejected, and must be immediately removed from the work.

CONCRETE.

All concrete shall be made of one part of cement, two parts of sand and four parts of broken stone or brick, by volume, all to be of the quality and kind hereinbefore specified.

MORTAR.

The mortar shall be composed of one part of cement and two parts of sand, by volume. The sand and cement to be thoroughly mixed dry in proper boxes, after which a sufficient quantity of water shall be added to produce a mortar of proper consistency and the whole thoroughly mixed.

The mortar shall be mixed fresh for the work in

PAVEMENT.

On the concrete foundation thus prepared, a bed of clean, sharp sand, free from moisture, two inches deep shall be laid. The granite blocks shall be set stone to stone and hammered tight; the end and longitudinal joints shall be as close as possible; and the longitudinal joints shall be broken so as to leave a lap of at least three inches. The course shall be set at such angles to the line of the street as may be directed.

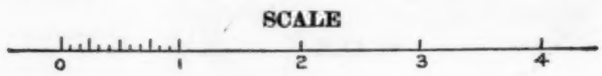
After a certain number of courses have been set, which shall be determined by the street commissioner, or his duly authorized agent, the joints shall be swept full of sand and each course rammed with a rammer weighing not less than seventy-five pounds. The first ramming being completed, the surface shall be sanded and then wet down with a hose until the water flushes

opposite faces closely approximating equal areas. All questions in regard to form of block, accuracy of dressing, or quality of stone, shall be determined by the street commissioner, or his duly authorized agent.

BRICK STREET CONSTRUCTION.

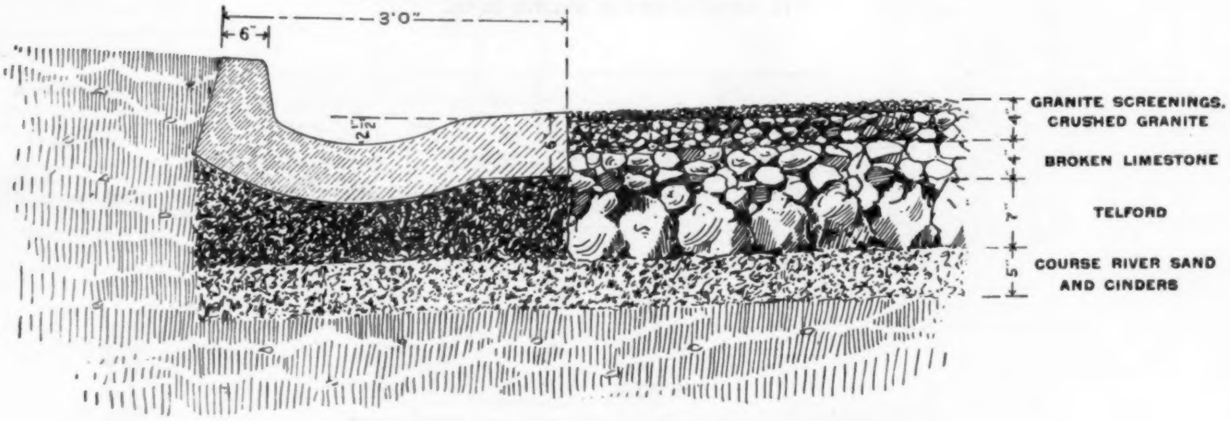
OOLITIC LIMESTONE CURBING.

All curbstones shall be of the best quality of hard dark-blue oolitic limestone from quarries of established reputation, free from seams or other defects. All curbing shall have close end joints to the full depth of the stone, and no stone shall be less than four and one-half feet long nor less than eight inches thick, and not less than sixteen inches deep. Each stone shall have parallel sides. The edge toward the roadway shall be rounded with a radius of one and one-half inches. The



IMPROVED TELFORD

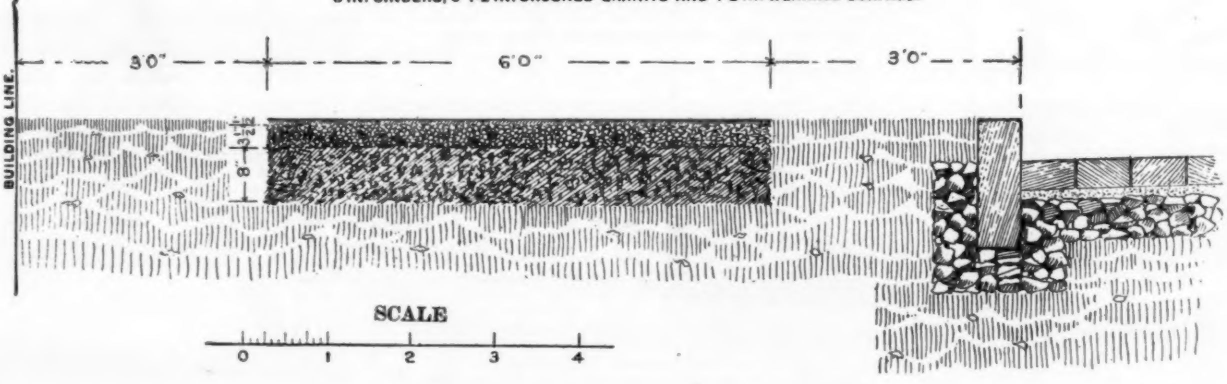
3 FT. GRANITOID CURB & GUTTER ON 8 IN. CINDERS.



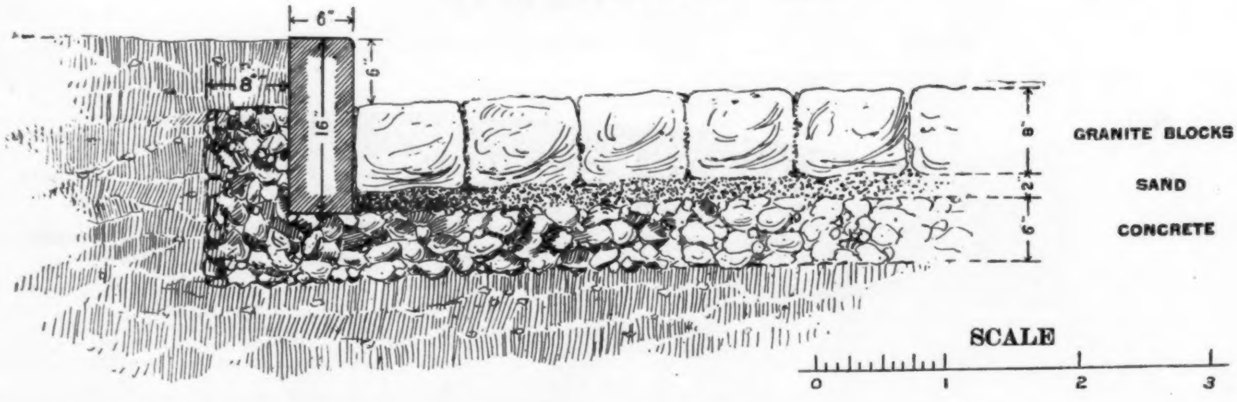
CROSS-SECTION OF

GRANITOID SIDEWALK.

8 IN. CINDERS, 3 1-2 IN. CRUSHED GRANITE AND 1-2 IN. WEARING SURFACE.



GRANITE PAVEMENT



hand, and any mortar which has begun to set shall not be used.

The mortar shall be thoroughly worked and the broken material added, and the whole mass mixed by turning not less than three times on the platform on which the concrete is made. The concrete shall be mixed on a platform prepared for that purpose.

The concrete shall be deposited in place and shall conform to the grade and cross section of the street, to be compacted so as to produce a smooth surface and a uniform distribution of the materials throughout the mass.

No walking or driving over concrete in place shall be permitted when it is setting, and it shall be allowed to set for at least twelve hours and such additional length of time as may be directed by the street commissioner before the pavement is put down. All materials used in the construction of the pavement shall be brought on to the concrete in barrows, or delivered on the concrete from the sidewalk.

to the surface, after which the ramming shall be repeated, course by course, until the pavement is compact and solid and in conformity with the line and cross grade of the street. The pavement shall then be covered with a uniform layer of coarse, sharp sand, three-fourths of an inch deep.

PAVING BLOCKS.

The blocks shall be of good sound granite, equal in quality and dressing to sample on exhibition at the office of the street commissioner, of uniform grain and texture, free from excess of mica or feldspar. No stone which shows any appearance of disintegration, nor blocks cut from surface stones or bowlders, will be accepted. The blocks shall not be less than nine inches nor more than twelve inches long; not less than three and one-half inches nor more than four and a half inches wide; not less than seven and a half inches nor more than eight and a half inches deep, and dressed so as to approximate closely a rectangular form with

curbing shall be set on concrete six inches deep and fourteen inches wide, and backed with concrete six inches wide and ten inches deep, or six inches below top of curbing.

Curb to be dropped four inches or more at all driveways, unless otherwise ordered. The quality of the curb shall be equal to the sample in the street commissioner's office.

CONCRETE FOUNDATION.

Upon the roadbed a foundation of hydraulic cement concrete shall be laid to a uniform depth of six inches. (See Concrete Foundation in Granite Street Construction.)

VITRIFIED BRICK WEARING SURFACE.

Upon the foundation of concrete shall be laid a bed of coarse, screened sand, one and one-half inches in thickness when compacted, to serve as a bed for the bricks. Upon this base of sand a pavement of the best quality of vitrified paving brick shall be laid. The

bricks shall not be less than eight inches nor more than nine inches long, not less than two and one-half inches nor more than three and one-half inches wide, not less than four inches nor more than four and one-half inches deep, with rounded edges with a radius of three-eighths of an inch. Said brick shall be of the kind known as "repressed" brick, and shall be repressed to produce a mass free from internal flaws, cracks or laminations.

The bricks shall be free from lime or other impurities that will injuriously affect them when immersed in water, uniform in size and quality, and thoroughly burned and annealed.

All brick so distorted in burning, or with such prominent kiln marks as to produce an uneven pavement, shall be rejected.

Each bidder shall submit one hundred bricks, which shall be subjected to such physical tests as may, in the opinion of the street commissioner, be necessary to determine their quality and suitability for the work.

To secure uniformity in bricks of approved manufacture, delivered for use, the following tests shall be made:

1. They shall show a modulus of rupture in cross-breaking of not less than twenty-five hundred pounds per square inch.

2. Specimen bricks shall be placed in the machine known as a "Rattler," twenty-eight inches in diameter, making thirty revolutions per minute. The number of revolutions for a standard test shall be eighteen hundred, and if the loss of weight by abrasion or impact during such a test shall exceed thirty per cent. of the original weight of the bricks tested, then the bricks shall be rejected. An official test to be the average of two of the above tests.

No bid contemplating the use of rejected brick shall be entertained.

Samples may be submitted by manufacturers, in which case the bidder proposing to use brick of such manufacture will not be required to submit samples. The quality of the brick furnished must conform to the samples presented by the manufacturers and kept in the office of the street commissioner.

The street commissioner reserves the right to reject any and all bricks which, in his opinion, do not conform to the above specifications.

Any brick may have a proper shrinkage, but shall not differ materially in size from the accepted samples of the same make, nor shall they differ greatly in color from the natural color of the well burned brick of its class and manufacture.

No bats or broken bricks shall be used, except at the curbs, where nothing less than a half brick shall be used to break joints. The bricks to be laid in straight lines and all joints broken by a lap of at least two inches, to be set on edge on the sand as closely and compactly as possible and at right angles with the line of the curb, except at street intersections, where they are to be laid as the street commissioner may direct.

The pavement to be thoroughly rammed two or three times with a paver's rammer weighing not less than seventy-five pounds. The pavement to be surfaced up by using a long straight edge and by a thorough rolling of the pavement with a road roller weighing not less than three nor more than six tons, and when completed to conform to the true grade and cross section of the roadway.

All the joints in the pavement shall be completely filled with Portland cement grout. The cement to be of brand approved by street commissioner, to be fine ground; 85 per cent. shall pass through a sieve having 10,000 meshes to the square inch. All cement shall be capable of withstanding a tensile strain of 500 pounds per square inch of section, when mixed neat, made into briquettes and exposed 24 hours in air and 6 days under water. All cement shall be put up in well made barrels, and all short weight or damaged barrels will be rejected. Cement without manufacturer's brand and certificate will be rejected without test.

The grout shall be mixed in portable boxes in the proportion of 1 part cement to 1 part sand. The cement and sand to be thoroughly mixed together dry, then sufficient water to be added to make the grout of proper fluidity when thoroughly stirred.

The grout shall be transferred to the pavement in hand scoops, or as the street commissioner may direct, and rapidly swept into the joints of the pavement with proper brooms.

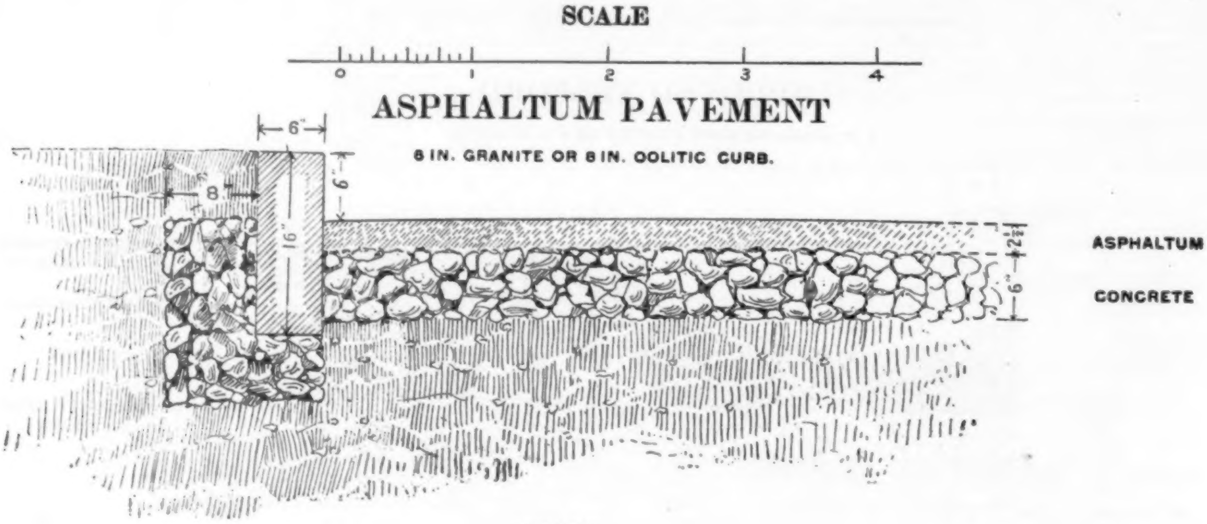
Teams, carts and wagon traffic and wheeling in barrows, except on plank, will not be allowed on the pavement for at least 7 days after the grout is applied.

The surface of the pavement, when completed, shall be covered with ½ inch of clean, coarse sand, of approved quality, which, with all dirt, shall be removed from the pavement and sewer inlets by or at the expense of the contractor at such time before the final acceptance of the work as the street commissioner may direct.

SCALE

ASPHALTUM PAVEMENT

6 IN. GRANITE OR 8 IN. OOLITIC CURB.



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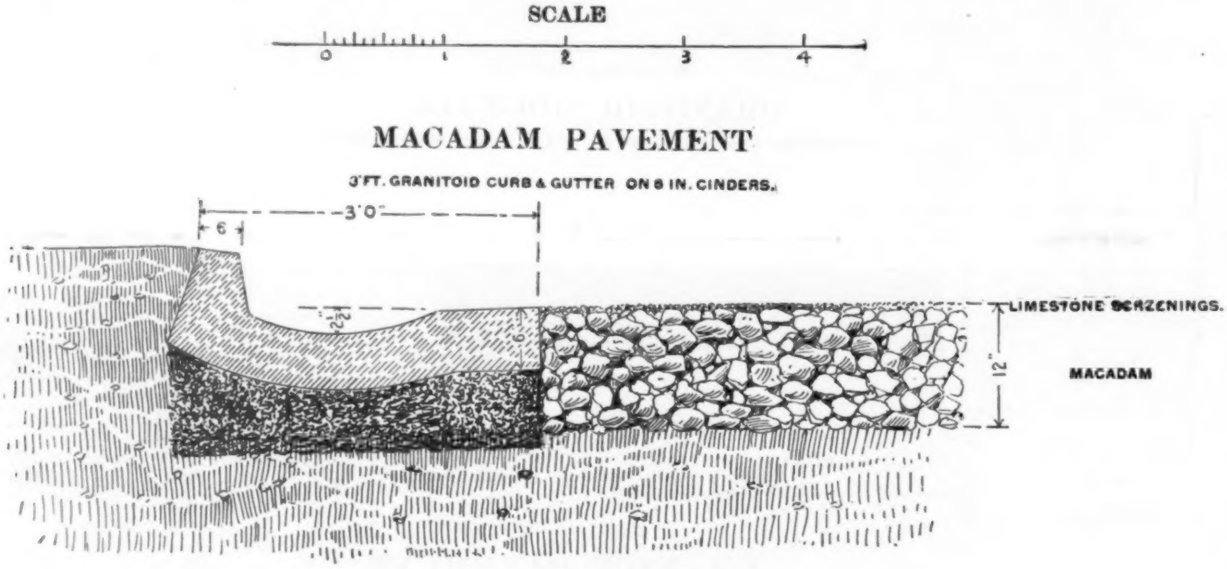
MACADAM PAVEMENT

3 FT. GRANITOID CURB & GUTTER ON 8 IN. CINDERS.



PARK ROAD

2FT. X 6IN. GRANITOID GUTTER

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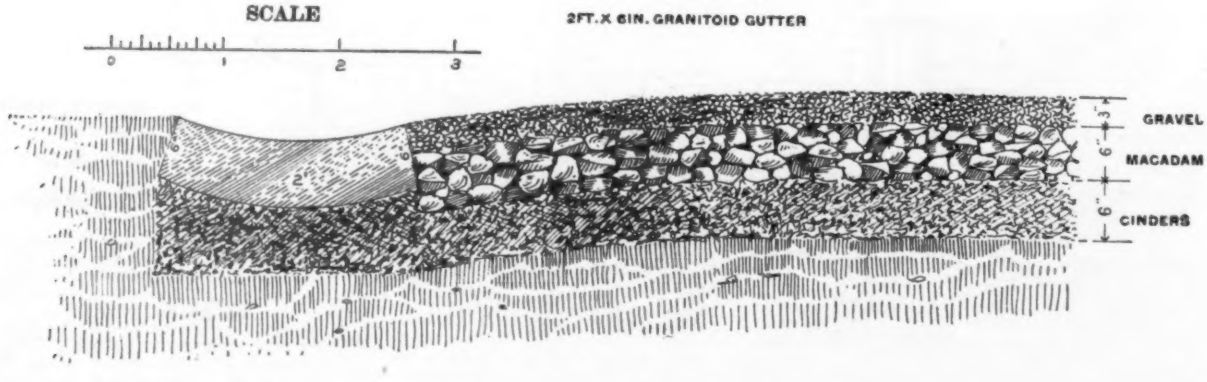


Rock Asphaltum Pavement.

The foundation is the same as granite or brick.

Wearing Surface.

Upon the base thus formed shall be placed a wearing surface as follows:

A mixture of American bituminous rock, which shall be prepared and laid on said concrete base as follows: The wearing surface shall be composed of bituminous sand rock from the Chickasaw Nation or Breckinridge County, Ky., 66⅔ to 50 per cent.; bituminous lime rock from the Buckhorn mines in the Chickasaw Nation, 33⅓ to 50 per cent. The rock of both materials shall be ground finely and thoroughly mixed and nothing shall be added to or taken from the powder obtained by grinding the bituminous rock. This pow-

der shall be heated in a suitable apparatus to a temperature of from 150° to 200° Fah.; it shall be brought to the street in suitable carts and spread with rakes to an even thickness of such depth as will insure a uniform thickness of 2 inches after having received its ultimate compression. The surface shall then be compressed by tamping and rolling, after which a small amount of hydraulic cement will be swept over it, and then it will be thoroughly compressed by a steam roller weighing not less than 5 tons.

The bituminous sand rock shall contain from 9 to 12 per cent. of pure bitumen. The bituminous lime rock shall be as nearly as possible a pure carbonate, thoroughly and evenly impregnated with asphalt having no more impurities than the standard German rock asphalt of Limmer or Vorhole, and shall contain not less than 7 per cent. and not more than 12 per cent. of bitumen, according to the richness of the bituminous sand used.

The other illustrations show a Telford pavement with vitrified brick gutter; an improved Telford pavement with granitoid curbs; a Macadam pavement with granitoid curbs, and a park road. They are model pavements, and, with the aid of the foregoing specifications, no further description seems necessary. Valuable papers on roadways and street pavements will be found in our SUPPLEMENT, Nos. 971, 628, 578, 476, 567, 843, 626, and 845.

[Continued from SUPPLEMENT, No. 1135, page 18137.]

PERPETUAL MOTION.—V.*

CARNOT'S OPINION OF PERPETUAL MOTION.

THE celebrated physicist and mathematician Carnot has given his opinion on "perpetual motion" as follows:

From what we have observed regarding friction and other passive forces, it may be inferred that perpetual motion is a thing absolutely impossible, when only such bodies are employed as are not acted on by motive power, or any heavy body; for, as these passive forces, which cannot be avoided, are constantly resisting, it is evident that the movement must continually abate; and from what has been said, it will be seen that, when

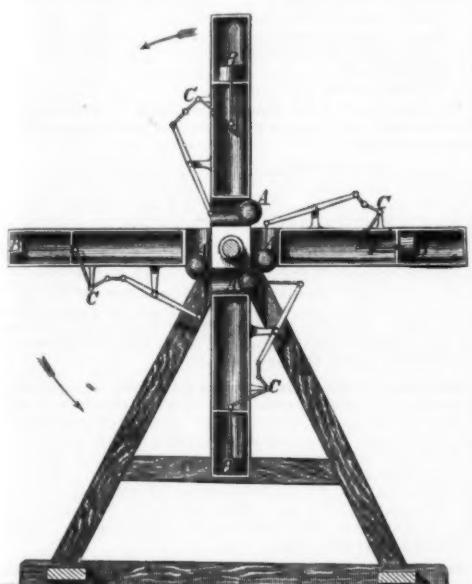


FIG. 22.

bodies are not acted on by any motive power, the sum of active force will be reduced to nothing; that is to say, that the machine will be brought to rest when the amount of activity absorbed by friction, since the commencement of the movement, will have become equal to one-half of the initial active force; and when the bodies are weights, the movement will terminate when the amount of activity absorbed by the friction equals one-half of the initial active force. Moreover, one-half of the active force existing, if all the parts of the system have a common speed, equals that which is due to the height of the point where, in the first instance of the movement, was the center of gravity above the lowest point to which it can descend.

It is easy to apply the same reasoning to constructions where springs are used, and generally to all such constructions where, abstracting from friction, the moving force, in order to bring the machine from one position to another, must consume an amount of activity as great as that which is absorbed by the resisting forces when the machine returns from the last to the previous position.

The movement will terminate still sooner, if any percussion takes place, as the sum of active force is always diminished in such cases.

It is therefore evident that one must altogether despair of producing what is called the perpetuum mobile, if it be true that all the motive powers existing in nature consist in nothing but attraction, and that it is a general property of this power to be always equal at equal distances between given bodies: that is to say, to be a function that only varies in cases where the distance of these bodies varies itself.

This opinion may be appropriately followed by that of Dr. Lardner, given in the following extract:

There is no mechanical problem on which a greater amount of intellectual ingenuity has been wasted than that which has for its object the discovery of the perpetual motion. Since this term, however, is not always rightly understood, it will be useful here to explain what the perpetual motion is not, as well as what it is.

The perpetual motion, then, which has been the subject of such anxious and laborious research is not a mere motion, which is continued indefinitely. If it were, the diurnal and annual motion of the earth, and the corresponding motions of the other planets and satellites of the solar system, as well as the rotations of the sun upon its axis, would be all perpetual motions.

To understand the object of this celebrated problem,

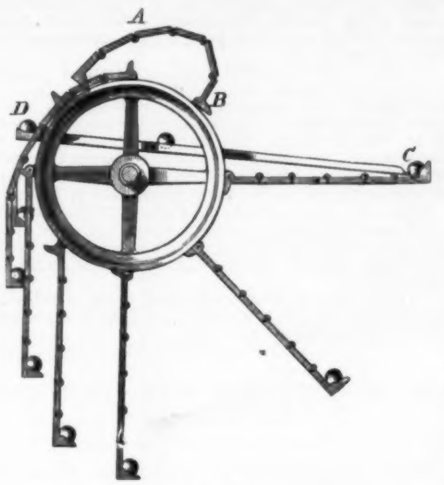


FIG. 23.

it is necessary to remember that, in considering the construction and performance of a machine, there are three things involved: 1st, the object to which the machine gives motion; 2d, the construction of the mechanism; and 3d, the moving power, the effect of which is transmitted by the machine to the object to be moved. In consequence of the inertia of matter, the machine cannot transmit to the object more force than it receives from the moving power; strictly speaking, indeed, it must transmit less force, since more or less of the moving force must be intercepted by friction and atmospheric resistance. If, therefore, it were proposed to invent a machine which would transmit to the object to be moved the whole amount of force imparted by the moving power, such a problem would be at once pronounced impossible of solution, inasmuch as it would involve two impracticable conditions: first, the absence of atmospheric resistance, which would oblige the machine to be worked in a vacuum; and second, the absence of all friction between those parts of the machine which would move in contact with one another.

But suppose that it were proposed to invent a machine which would transmit to the object to be moved a greater amount of force than that imparted by the moving power, the impossibility of the problem would in this case be still more glaring; for, even though the machine were to work in a vacuum, and all friction were removed, it could do no more than convey to the object the force it receives. To suppose that it could convey more force, it would be necessary to admit that the surplus must be produced by the machine itself, and that, consequently, the matter composing it would not be endowed with the quality of inertia. Such a supposition would be equivalent to ascribing to the machine the qualities of an animated being.

But the absurdity would be still greater, if possible, if the problem were to invent a machine which would impart a certain motion to an object without receiving any force whatever from a moving power; yet such is precisely the celebrated problem of the perpetual motion.

In short, a perpetual motion would be, for example, a watch or clock which would go as long as its mechanism would endure, without being wound up; it would be a mill which would grind corn, or work machinery, without the action upon it of water, wind, steam, animal power, or any other moving force external to it.

It is not only true that such a machine never has been invented, but it is demonstrable that so long as

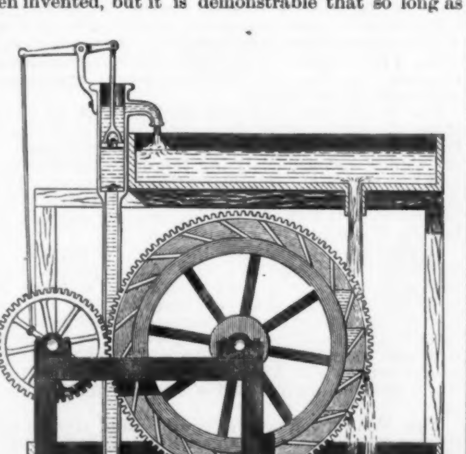


FIG. 24.

the laws of nature remain unaltered, and so long as matter continues to possess that quality of inertia which is proved to be inseparable from it, not only in all places and under all circumstances on the earth, but throughout the vast regions of space to which the observations of astronomers have extended, the invention of such a machine is an impossibility the most absolute.

Fig. 22 is a drawing of a supposed perpetual motion, which the inventor says will not go, though he has worked at it twelve months. He has now given it up in despair, and vows he will waste no more time upon it. The central weights, A, each weigh one-fourth more than the weights, B, at the extremities of the arms. The two sets of weights are connected pairs, each pair being joined by a lever, link and bell crank, C. The action of gravity in the central weights compels the sliding weights at the ends of the arms to assume the positions shown in the engraving.

Had our correspondent, Mr. George C. Phillips, of Alleghany, Cal., applied a little mathematical calculation to the verification of the truth or falsity of the principle of his device, he might easily have proved that it was a perfect balance, and saved himself twelve months of trouble and expense. The leverage of the outside is exactly counteracted by the leverage of the inside weights.

Fig. 23 is a device contrived by Mr. George Linton, of Middlesex, England. The engraving is an end view of a series of vertical wheels, one only being seen. The lever, A, is represented in the act of falling from the periphery of the wheel into a right line. The lever is composed of a series of flat rods, connected by ruler joints, which said ruler joints are provided with a stop, or joggle, to prevent their collapsing at any time more than will bring any one of the rods which compose the levers at a right angle with the rod next to it. This lever is attached to the periphery of the wheel by the hinge joint, B, provided with the shoulder, to prevent its falling into any other than a right line from the center of the circumference of the wheel. The levers are furnished at their outer extremities with a bucket, or receiver, the bottom of which is sufficiently broad to retain the ball, C. The balls remain in the buckets till the buckets come into the position of the lever, D, when they are expected to roll out of the buckets on to the inclined plane, and by their own gravity roll to the other end of the inclined plane, ready to be again taken into the buckets.

Fig. 24 shows a principle so often employed for the production of self-moving machines that it ranks next to that of perpetual eccentric weights in its delusive power upon minds of inventors. The attempt to compel a water wheel to raise the water which drives it is in one form or other perpetually recurring in devices

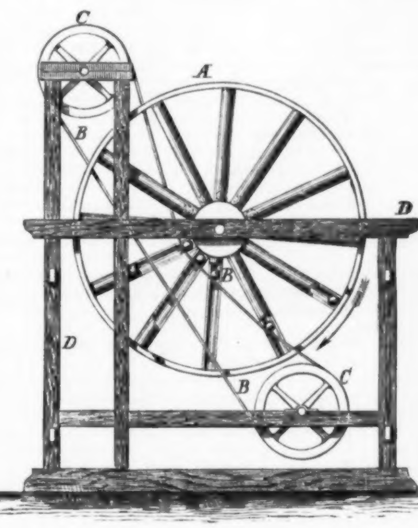


FIG. 25.

upon which our counsel and opinion are sought. The worst of the matter is that in most cases our advice to drop such absurd projects is received as evidence of our want of sagacity and knowledge, and our would-be client becomes the dupe of some not over-conscientious patent agent, who pockets his fees and laughs in his sleeve at the greenness of the applicant.

The device illustrated is one submitted by one of these enthusiastic individuals, who, without understanding the first principles of mechanics, believes he is about to revolutionize the industry of the world by his grand discovery; and as honor, and not pecuniary reward, is his object, he seeks to make public his invention through the wide circulation of this journal. He is quite willing we should adversely criticise the device, because its merits are so great that no amount of skepticism resulting from our blind prejudice can, he thinks, influence candid minds against a principle so obviously sound and sublimely simple. It is unnecessary for us to describe the device, as it explains itself. The inventor has not tried it to see whether it will work. What need when any one can see on paper that "it must go"?

Fig. 25 represents an attempt at securing the desired object by means of eccentric weights, kept so by means of an endless belt and pulleys, of which the inventor thus writes:

"The annexed drawing shows how I have at length taken this enticing jilt (perpetual motion), though after a long and weary chase

'Through pleasant and delightful fields,
Through barren tracks and lonely wilds;
'Mongst quagmires, mosses, muirs and marshes,
Where deil or spunkie never scarce is!
By chance I happened on her den
And took her where she didna ken.'

"A represents a wheel with twelve hollow spokes, in each of which there is a rolling weight or ball. B is a belt passing over two pulleys, C. There is an opening round the wheel from the nave to the circumference, so as to allow the belt to pass freely and to meet the weights. The weights are met by the belt as the wheel revolves, and are raised from the circumference until they are at last brought close to the nave, where they remain till, by the revolution of the wheel, they are allowed to roll out through the circumference. By this

* Reprinted from the SCIENTIFIC AMERICAN, 1870-71.

arrangement the weights are one side of the wheel, always at the circumference, so that that side is more powerful than the other, which causes the wheel continually to revolve. D is the frame of the machine. The arrow points out the direction in which the wheel turns."—Dixon Vallance, Liberton, Lanarkshire, November 10, 1825.

In 1612 Thomas Tymme, professor of divinity, published a philosophical dialogue, in which he discourses of the perpetual motion invented by Cornelius Van Drebble, a Dutchman, who was engineer to King James in England.

Tymme's work is a small quarto. The author's name on the title papers occurs in the smallest type. It is repeated again in full—"Thomas Tymme"—both to the dedication "To the Right Honorable Sir Edward Coke, Lord Chief Justice," etc., etc., and also The Address to the Readers, which latter concludes:

"And for that rare things move much, I have thought it pertinent to this Treatise, to set before thee a most strange and wittie invention of another Archimedes which concerneth Artificial perpetual motion, imitating nature by a lively patterne of the Instrument It Selfe, as it was presented to the King's Most Royall hands, by Cornelius Drebble, of Alchmar in Holland, and entertained according to the worthinesse of such, a gift my paines herein bestowed and intended for thy profit and pleasure, if it seeme but as iron, yet let it serve for the Forge and Anvil of good conceit, if the discourse seeme rough, shadow it, I pray thee, with the curtaine of smooth excuse," etc.

The work is divided into two parts, the first containing six, the second four chapters.

"Chap. 3 concerneth the nature and qualitie of the earth: and the handling of a question whether the earth hath naturall motion or no.

"Also herein is described an Instrument of Perpetuall Motion, as stated in the list of Contents."

At page 56 commences chapter 3, from which we extract the following:

"Philadelphia—For as much as the Earth and Sea make but one globous body united and combined together, I pray you describe the form thereof to me."

This is explained by Theophrast—the dialogue occupying four pages. At last he says:

". . . And to make plaine the demonstration unto you, that the Heavens move and not the earth, I will set before you a memorable Modell and Patterne, respecting the motion of the Heavens about the fixed earth, made by Art in the immitation of Nature, by a gentleman of Holland, named Cornelius Drebble, which instrument is perpetually in motion without the meanes of Steele, Springs, and waights.

"Phil.—I much desire to see this strange Invention. Therefore, I pray thee, good Theophrast, set it here before me, and the use thereof.

"Theo.—It is not in my hands to show, but in the custody of King James, to whom it was presented. But yet behold the description thereof here after fixed.

"Phil.—What use hath the globe marked with the letter A?

"Theo.—It representeth the Earth; and it containeth in the hollow body thereof divers wheels of brasse, carried about with moving, two pointers on each side of the Globe does proportion and shew forth the time of dayes, moneths, and yeeres, like a perpetualle Almanacke.

"Phil.—Both doth it also represent and set forth the motions of the Heavens?

"Theo.—It setteth forth these particulars of Cellestiall motion. First the houres of the rising and setting of the Sunne, from day to day continually. Secondly, hereby is to be seene, what signe the Motion is in every 24 houres. Thirdly, in what degree the Sunne is distant from the Moone. Fourthly, how many degrees the Sunne and Moone are distant from us every houre of the day and night. Fifthly, in what signe of the Zodiacke, the sun is every Moneth.

"Phil.—What doeth the circumference represent, which compasseth the Globe about?

"Theo.—That circumference is a ring of Cristall glass, which being hollow, hath in it water, representing the sea, which water riseth and falleth, as doth the floud, and ebbe twice in 24 houres, according to the course of the tides in those parts, there this instrument shall be placed, whereby is to be seene how the Tides keepe their course by day or by night.

"Phil.—What meaneth the little globe above the ringe of the Glasse?

"Theo.—That little Globe as it carrieth the forme of moone cressent, so it turneth about once in a moneth, setting forth the encrease and decrease of the Moone's brightnesse, from the wane to the full, by turning round every moneth in the yeere.

"Phil.—Can you yeeld me any reason to perswade me concerning the possibility of the perpetuity of this motion?

"Theo.—You have heard before that fire is the most active and powerful Element, and the cause of all motion in nature. This was well knowne to Cornelius, by his practise in the untwining of the elements, and therefore to the effecting of this great worke, he extracted a fierie spirit, out of the minerall matter, joining the same with his proper aire, which encluded in the Axletree, being hollow, carrieth the wheeles, making a continuall rotation or revolution, except issue or vent be given to the Axletree, whereby that imprisoned spirit may get forth. I am bold thus to conjecture because I did at sundry times pry into the practise of this gentleman with whom I was very familiar. Moreover, when as the King, our Soveraigne, could hardly believe that this motion should be perpetuall, except the misterie were revealed unto him; this cunning Bezaleel, in secret manner, disclosed to his Majestie the secret, whereupon he applauded the rare invention. The fame thereof caused the Emperor to entreat his most excellent Majestie to license Cornelius Bezaleel to come to his Court, there to effect the like Instruments for him, sending unto Cornelius a rich chaine of gold.

"Phil.—It becometh not me to make question concerning the certaintie of that, which so might Potentates out of the limity of their wisedomes have approved, yet me thinketh that time and rust which corrupteth and weareth out all earthly things, may bring an end to this motion in a few yeeres.

"Theo.—To the end of time may not weare these wheeles by their motion you must know that they move in such slow measure that they cannot weare and the lessee, for that they are not forced by any poyse of waight. It is reported in the Preface of Euclydes Elements, by John Dee, that he and Hieroninus Cardanus saw and Instrument of perpetuall motion, which was solde for 20 talents of gold, and after presented to Charles Fift Emperour; wherein was one wheele of such invisible motion that in 70 yeeres onely his owne period should be finished. Such slow motion cannot weare the wheeles. And to the end rust may not cause decay, every Engine belonging to this Instrument is double gilded with fine gold, which preserveth from rust and corruption.

"Phil.—This wonderful demonstration of Artificiall motion, immitating the motion celestiall, about the fixed earth doth more prevaill with me to approve your reasons before alleadged, concerning the moving of the Heavens, and the stability of the Earth then can Copernicus assertions which concerne the motion of the Earth. I have heard and read of manie strange motions artificiall as were the inventions of Boetius."

After enumerating these and others Phil. concludes:

"These were ingenious inventions, but none of them are comparable to this perpetuall motion here described, which time by triall in ages to come, will much commend.

"Theo.—These great misteries were attained by spending more oyle than wine: by taking more paines than following pleasure."

(To be continued.)

SHOULD GENERATING PLANT BE MOUNTED ON SPRINGS?*

By JAMES SWINBURNE, M.Inst.C.E.

THIS is really part of a larger question: Should moving machinery be mounted on springs? The question concerns both the health of the moving machinery and of the people who may be moved by it. In central stations and in passenger steamers the shaking caused by machinery is most serious; in flour mills, for example, it is rather a question concerning the gear itself.

If we consider, say, a direct-acting pump in space, it is a system that of course cannot move its center of gravity as a whole. If, then, its pistons and plunger move in one direction, the rest must move in another direction, the distance depending on their masses. Any imperfectly balanced machinery must therefore move its bedplate if freely suspended. A perfectly balanced engine is thus an engine whose center of gravity never varies relatively to its bedplate. This definition is really too small, because a moving system, such, for instance, as two cranks at 120 deg. on opposite ends of a shaft, do not change their center of gravity, but give the bedplate a rocking but nontranslational movement. A gas engine with a flywheel, similarly, tends to rotate its bedplate at each impulse round an axis parallel to that of the shaft. A balanced engine is therefore really one which does not move its bedplate if freely suspended. Such an engine is practically never realized.

When an engineer sees an engine bedplate moving, his first instinct is to bolt it down; it then moves a little less, but still moves, and he has a sort of feeling it must shake itself to pieces if allowed to move. Bolting down an engine to a bed of concrete is merely increasing the size of its effective bedplate, but the whole bedplate, including the concrete, must now be moved. It rests on the earth, moves slightly, and communicates vibration to neighbors who are longing to be compensated for disturbance.

Sometimes the concrete bedplate is isolated by mounting it on felt; that means that the larger bedplate is mounted on rather imperfect springs.

A rather striking case is that of church bells. Bells are very much out of balance, and the bedplates are mere cages of timber; so the bedplates would tend to move a good deal. The bell people do not like to see it move, so they wedge it to the steeple, and the result is a cracked steeple. The consequence is that you often hear that such a church has a very fine peal of bells, but they cannot be used, as the steeple will not stand it. Though this may be a relief to people whose ears are in tune, it might be cheaper not to make bells than to make them and hang them so that they cannot be used.

The question is, if the bedplate of an engine wants to move, why should it not have free play? As far as the engine goes, a little thought will show that all its parts are subjected to smaller stresses if the bedplate is free to move. An engine will therefore wear longer if it is allowed to move its bedplate. As to the foundations, if the bedplate is allowed to move, no foundations to speak of are needed; and there is no vibration communicated to the ground.

The writer has tried this arrangement on a small scale. There is a small dynamotor on one of the top floors of Mr. Crookes' house which is very much out of balance, and rendered the house uninhabitable at first. It is now on springs and makes no noise. There is also a dynamotor for electrolytic work in the writer's laboratory. It has no springs, and no one has any inkling of a chance of complaining.

In passenger steamers the throb of the engine is exceedingly unpleasant; in fact, many people would rather go by a slower boat than travel 21 knots and be at the same time shaken 42 more knots by his pedometer. Mounting marine engines on springs seems rather a bold suggestion, and perhaps we ought not to begin there. The moving systems are so heavy in proportion to the fixed (or "attached" is the better word) that the marine engine is a particularly difficult case.

The idea of mounting engines and dynamos on springs was mooted by the writer in Industries in 1892. The editor, in addition to being a sound engineer, is a man of caution, so the communication came out as an anonymous letter. Mr. W. W. Beaumont has, however, done a great deal of real work on the subject, especially in connection with flour mills. He has introduced his "vibromotor" principle. This principle is simple. "If gear wants to wobble, let it wobble." The idea seems sound. The discussion will perhaps throw new light on it.

The administration of oxygen is of great benefit in the case of carbon monoxide poisoning.—Stahl und Eisen.

* Paper read at the Institution of Civil Engineers. Engineering Conference. Section VII. Applications of Electricity.

SELECTED FORMULÆ.

Electro-plating Aluminum with Copper.—According to a continental contemporary, it is possible to obtain adhesive coats of copper on aluminum by the following method: First clean the aluminum in a warm solution of an alkaline carbonate, thus making its surface rough and porous; it is next washed thoroughly in running water, and dipped into a hot solution of hydrochloric acid of about 5 per cent. strength, again washed in clean water, and then placed in a somewhat concentrated acid solution of copper sulphate, until a uniform metallic deposit is formed; it is then again thoroughly washed and returned to the copper sulphate bath, when an electric current is passed until a coating of copper of the required thickness is obtained.

Photographic Intensification.—A method of optical intensification of a weak negative, due to Lord Rayleigh, is too valuable to be overlooked. It is based upon a well known principle. A piece of colored glass looks twice as intensely colored when placed upon a sheet of white paper. A feeble transparency is similarly intensified. In both cases the light rays have to traverse the absorbing layer twice over. For the white paper a silver-on-glass mirror may be advantageously substituted. The film of the negative is placed in contact with the silver, and illuminated by a candle or other small source of light. It is then photographed in the usual manner. To get rid of surface reflection a wedge shaped plate of glass is laid over the negative.—Rayleigh, Phil. Mag., Sept., 1897.

Model Face Powder.—The Pharmaceutische Rundschau says that a good face powder must contain snow-white steatite, light calcium carbonate, zinc white and wheat or rice starch. Flesh color for blonds is produced by carmine and the tint for brunettes by burnt umber or sienna. Orris is best for scent. The following ideal cosmetic powder is constructed from these ingredients:

Zinc white	500 parts.
English precipitated calcium carbonate	3000 "
Steatite, best white	500 "
Wheat or rice starch	1000 "
Triple extract white rose	30 "
Triple extract jasmine	30 "
Triple extract orange flower	30 "
Extract cassia	30 "
Tincture musk	8 "

Mix thoroughly by repeated siftings. Orris root in powder may be substituted for the perfumes.—Pharmaceutical Era.

Pumice Stone for Filtering.—English pharmacists are generally familiar with the valuable properties of pumice stone as a filtering medium, which Busch (Pharm. Centralh., xxxviii, 424) has lately recommended as a novelty for filtering liquids which contain minutely distributed precipitates (such as barium sulphate, lead sulphate, calcium oxalate), likely to pass through the filter. The very finest pumice stone powder must be used, and it must have been freed from all acid-soluble impurities. Two to three grains of the powder are put on the point of the filter, and a clear filtrate is said to be obtained after the first few drops.

Detection of Glycerine in Sirupy Liquids.—Deniges recommends heating a small quantity of the liquid with three or four times its weight of powdered bisulphate of potassium. Any acrolein vapors which may have formed are detected by Nessler's reagent, or they are passed into a hot mixture of 2 c.c. of a 1 to 2 solution of silver nitrate, 2 c.c. of solution of ammonia and 2 c.c. of solution of soda. The reduction of the silver solution indicates the presence of glycerine.—Pharm. Centralh., xxxviii, 427.

New Dental Filling Material.—The following mixture under the name of "aluminized gutta percha" is recommended by Bliss as a filling:

White gutta percha	8
Aluminum filings	5
Oxide of zinc	1
Whiting	½

The filling is said to be easily manipulated, free from bulging and to hold its position in the cavity when firmly packed.—Journ. Brit. Dent. Ass., xviii, 401, after Pac. Stomat. Gaz.

Coloring Silver.—A rich gold tint may be imparted to silver articles by plunging them into dilute sulphuric acid, saturated with iron rust.—La Science en Famille.

Blacking Copper.—To give a copper article a black covering, clean it with emery paper, heat gently in a Bunsen or a spirit flame, immerse for 10 seconds in a solution of copper filings in dilute nitric acid, and heat again.—Revue Scientifique.

Waterproof Floors.—Flooring may be made impermeable by painting it with a solution of paraffin wax in kerosene. The coat lasts for two years.—Uhland's Wochenschrift.

Soldering Cast Iron.—To solder cast iron, clean the place to be soldered well, then brush it with a brass wire brush until the iron becomes yellow. It will be found that the solder can now be applied without any trouble.—La Science en Famille.

Developing Powders.—A developer in powder form, suitable for taking on tours, is prepared as follows:

A

Metol	7 parts.
Hydroquinone	18¼ "
Powdered eikonogen	10½ "
Powdered boric acid	4⅛ "

Mix this well and keep in a well stoppered yellow bottle.

B

Sulphite of soda	45 parts.
Borax	10½ "
Sugar of milk	10½ "

This may be kept in a white bottle. For use take:

Water	100 parts.
Powder A	2 "
Powder B	4 "

For bromide paper use double the amount of water.—La Vie Scientifique.

ENGINEERING NOTES.

An overhead cable tramway, from Dyea to the Klondike mines, is proposed by L. R. Radcliff, of St. Louis. The St. Louis Republic says that he is now preparing to ship his cables and machinery to Seattle and thence to the far North, with the intention of building his tramway in the next spring and have it in working order over the pass for the following winter. Meanwhile he also proposes warehouse stations along the proposed line, to be worked by burros for the transport of miners' supplies.

A railway to India, from Alexandria to Agra and Bombay, is proposed by C. E. D. Black, in a paper read before the English Society of Arts. The line would be 2,400 miles long, from Port Said to Kurrachee, and would cross upper Arabia to Basra, at the head of the Persian Gulf; and skirt the north shore of the gulf and the Arabian Sea to Kurrachee, on the border of India. Mr. Black advocates the route for political purposes mainly, though he thinks the revenue would be sufficient to pay a fair interest on its estimated cost of $75,000,000.

Success appears to have attended the experiment made last December on the New Haven Railroad, and duly reported at the time, in the sheathing of a passenger car with copper. In this case the usual sheathing was removed from a first-class car, the frame was redressed and blocked and the metal sheathing was prepared in the company's shop, the process being slow, as the work was out of the usual line. It was thought that the copper might add considerably to the weight of the car, but since the completion of the work it has been found that the thinner car sheathing is not desirable, for the reason that the lips of the grooves in the edge are inclined to curl, there not being sufficient lumber in the upper lip to make it firm. All the posts and corners, in fact, every exterior part of the passenger car made of wood, were covered with copper. The car has been run since January without interruption, and no appreciable evidence of expansion has been noted during exposure to heat or cold, and the stiffness of the material prevents bad appearance on the board. Some eight hundred to nine hundred pounds of metal are required.

The greatest steam hammer of Germany is still the one called "Fritz," at the Krupp Works, in Essen, but, although great care had been taken in providing a very strong foundation, it has settled almost 16 inches. The construction of the foundation was started in a hole 40 feet deep on a grill made of piling. Then there comes a deep layer of sawdust, upon which very large and heavy cast steel blocks solidly fastened to each other are resting. Next follow three alternate layers of heavy wooden planking and more steel blocks. On top there is a layer of cork 40 inches thick, carrying the anvil block, which weighs upward of 30 tons. This foundation has to carry a total weight of about 2,300 tons, and, in consequence of its settling, the hammer is but seldom used now, having been replaced by a hydraulic press able to exert a pressure of 12,500 tons. This hydraulic press is the largest at the present time in Continental Europe, England being the only country having one of the same size, at the foundry of Beadmore, at Parkhead. In this connection it may be interesting to note that the Bethlehem Iron Works have now a hydraulic press furnishing an equivalent of power of 14,000 tons pressure.

That galvanized sheets which are made of steel with the oxide formed in rolling removed, and then coated with spelter, are not more generally used in boiler or tank works is because the advantages thereof are not sufficiently understood, says the American Boilermaker. The extreme cheapness of steel plate and improvement in manipulating same has been followed by the general substitution of steel plate stacks and chimneys for brick. It is, however, well for boilermakers to remember that the action of moisture, especially when impregnated with sulphur arising from soft coal, has a destructive influence on steel plates, rusting rapidly, particularly in the lighter gages. This may be delayed by frequent painting or varnishing. The coating of spelter of steel sheets is impervious to moisture, and therefore the life of the metal is preserved indefinitely, especially where it may be painted with the ordinary commercial stack or boiler paints. We would remind boilermakers that, unless they call the attention of their customers to this fact, they will find a large and profitable part of their business leaving them on account of the short life of the ordinary steel stack as now made, because the first cost of the brick chimneys will be of less importance than the inconvenience and cost of having to replace a steel stack or chimney.

Various plans have been suggested at different times for the utilization of the energy developed by the rise and fall of the tides, but the intermittent character of the power has usually prevented any satisfactory solution of the problem. There is, however, one instance in which tide power has been quite successfully applied in a very simple manner. Along the river front at Liverpool there is a tendency for the accumulation of silt against the dock walls, requiring occasional dredging for its removal. Instead of using scoop dredges, this mud is removed at different periods by the use of tide power in the following manner: Along the base of the dock walls is laid a pipe, perforated with holes, directed outward, this pipe being connected with the interior of the dock system, and suitable valves being provided to permit or to check the flow of water. When the tide is very low, and consequently the head of water measured from the surface in the docks is at its greatest, a sudden opening of the connection permits a rapid flushing action by the water escaping through holes in the pipe at the base of the walls, scouring out the mud and driving it out into the river to be carried away. As the tides at Liverpool average about 25 ft. or more, it is evident that this simple form of dredging apparatus may be very effective, and as the time chosen for using it may be selected when the supply of water is greatest, it does not interfere with the regular use of the docks. Ultimately, no doubt the introduction of practical and economical forms of power storage will render the equalization of tide power commercially practicable, but at the present time this example serves to demonstrate the fact that solar and lunar attraction, as expressed by the tides, have been harnessed in a small way at least.

ELECTRICAL NOTES.

A telephone connection between Frankfort-on-the-Main (Germany) and the chief towns of Switzerland is planned.—Electrotechnische Rundschau.

Herr Otto Reincke remarks that wines and beer are cleared much more quickly of any suspended matter if under direct strong light. He has tried the effect of the light from an electric lamp, and has found that a very quick clarification could be effected by the action of its rays on the beverage.—Wochenschrift für Brauerei.

The great station of the Niagara Falls Power Company is being extended 286 ft., making its total length 426 ft., which will accommodate ten of the 5,000 horse power units, three of which are already in place and seven more contracted for, the Westinghouse Company supplying the generators and the I. P. Morris Company the turbines, as before.

In Baar, Switzerland, there is a 10,000 spindle cotton mill run by electric power from the Rhone, which is only 550 feet away, says the Electrical Review. There are three motors kept in a separate room to protect them from the dust, and of these one drives the openers, cards, combing machines, drawing and flier frames, and supplies 260 lamps; another drives the mules, and the third the ventilating fan and workshop.

It is said that interesting experiments are being carried on by the Carnegie Steel Company at its Homestead Works in heating steel billets by electricity, says the English Electrical Review. Economy in fuel and a saving in time required to heat the billets are claimed. It is also asserted that the billets are heated from the center to the outer surface, insuring equal heat throughout the mass. The steel thus treated is reported to be of better quality, from the fact that the exact temperature may be obtained without overheating.

At Genoa (Italy) a peculiar accident recently occurred. A troop of soldiers were on their way to their drill, and were led by Lieutenant Tallio. The latter was crossing the tracks of the electric cars, when his horse stumbled, and knocked its head against one of the iron posts which carry the wires. A long spark shot out of the post and killed the horse instantly. The lieutenant was unhurt. The company explained the fact, saying that in a recent thunderstorm the post had been struck by lightning, and the insulation destroyed, so that the horse short-circuited the rails and the wires.—Electrotechnische Rundschau.

The electric current is supplied by some companies at a tariff based on the use of lamps of a definite candlepower. In many cases, either intentionally or by error, lamps of too high a candlepower are used. Thus the company is defrauded of its due. A device has now been introduced which makes it impossible to use lamps of a higher candlepower than provided by the tariff. Within the threaded socket of the lamp are placed a series of rings, varying in number according to the candlepower of the lamp, such of low candlepower having more rings than those of higher candlepower. Consequently, a lamp inserted in a socket intended for one of higher candlepower produces no contact, and therefore gives no light.—Stahl und Eisen.

"The only tramway company in Siam," says Mr. J. Barrett, in the Street Railway Journal, "is the Bangkok Tramways Company, which has been organized several years and is doing a very successful business. It began with horse cars, but now has as good an electrical equipment as most lines in America. When the system was changed from horses to electricity, the contract for dynamos, rolling stock and work of alteration was given to an American firm, who sent out a competent engineer to superintend it. From the very first day that the line was operated by electricity it has paid handsome dividends, never less than 8 or 10 per cent. and running up in one or two years to 15 or 18 per cent. per annum. The Siamese government has been favorably disposed to the company from its inception, and the King is a large stockholder. The Siamese people seem to have no prejudice whatever against this or other modern systems of rapid transit, and crowd the cars at every trip. The line has been so prosperous that it is running all the cars possible. It has a single track, with switches about every quarter of a mile, the streets being too narrow for a double track. The road runs right away from the lower end of the city in the heart of the shipping interests to the royal palace, a distance of fully six miles, through the principal thoroughfare. . . ."

The principal feature of the Cowper-Coles gold recovery process is an aluminum cathode which overcomes one of the chief difficulties appertaining to the economical recovery of gold from weak cyanide solutions by electrolysis, says The Engineer. In the Siemens-Halske process lead foil or lead strips are used, the cutting up of which is a tedious matter. If several sheets are cut superimposed, the strips cling together, and have to be carefully spread out one by one, so that the surface may be exposed to the solution. A clean-up is made every seven to eight weeks, when the wood frames carrying the lead strips are withdrawn, the lead strips removed and new substituted, the auriferous lead being ultimately melted down, and conveyed to a central works to be cupeled. This method is both crude and expensive, the labor of fitting the strips into the frames is considerable, and the consumption of lead is a large item, having been computed by Mr. Von Gernet at the Worcester Mine at 1·10 of a penny per ton of ore treated. The Cowper-Coles process overcomes these difficulties, aluminum plates being substituted for the lead foil, advantage being taken of the fact that a loose oxide is formed on the surface of the aluminum which enables the deposited gold to be readily stripped or wiped from the cathodes as pure gold. Gold by this process has been successfully extracted from cyanide solutions containing only 0·01 per cent. of cyanide of potassium, 2¼ dwt. of gold to the ton of solution. The substitution of aluminum for lead foil, or strip, enables the gold to be obtained as pure gold, and also daily returns to be made of the amount of gold recovered; it also has the additional advantage of reducing the cost of labor and economizing the amount of cyanide of potassium used, as the solution is not contaminated by any base metals such as zinc, as in the other processes.

MISCELLANEOUS NOTES.

The population of Algiers has risen from 4,164,155 in 1891 to 4,394,129 in 1896. These numbers include the French troops; 345,337 are French, 3,755,917 are Mohammedans of French nationality; the remainder consists of Spaniards, native Jews, Italians, Tunisians, Moors, Maltese, Germans, and others.—La Science en Famille.

Herr Russner, in Mittheilungen aus der Praxis des Dampfkessel- und Dampfmaschinen-Betriebes, 1896, states by using a covering of zinc plate on steam pipes, leaving a layer of air between the pipe and the covering, the condensation can be much reduced. Experiments with this contrivance gave results which compare by no means unfavorably with those of the ordinary non-conducting coverings, while the new arrangements have certain advantages which the author points out.

There are several breweries in Japan which are in keen competition both as regards the inland supply and the export. Their prosperity is best shown by the rise in the fortunes of the greatest among them, the "Nihon-Bakuscha-Kwaischa." Five or six years ago this company was very near bankruptcy, but in 1895 it sold three times as much beer as in 1892, its shares advanced from 40 yen to 80 yen and from 12½ yen to 34 yen. The exports of German beer to India and other parts of Asia have gone down in the proportion of 9·5 : 8.

Herr Salzenberg has devised a system of incandescent gas burners in which the gas is used at a high pressure. For the source of pressure he uses the water pipes. With his burner a candle power of 850 to 1,000 is obtained by the combustion of 220 to 300 liters of gas and about a cubic yard of water per hour. From one mantle two and one-half times as much light can be obtained as from an arc lamp, the expenses being much lower—the arc lamps burning in Germany costing about fifteen cents per hour, the incandescent gas three cents.—Uhland's Wochenschrift.

A great many toys are now made in this country, including many mechanical devices. Many toys are still imported. Such things as woolly sheep and dogs, now as highly prized by children as ever, come from Germany, as do the skin-covered horses. They could be made here, but they can be produced cheaper abroad. As a rule, whatever can be made by machinery is made here, while toys made by hand are mostly imported. The minute a thing is brought within the reach of machinery, American manufacturers can pay their higher prices for labor and still beat the world. With the low prices of labor in foreign countries, handmade productions can be made cheaper in them. As a result of this there are toys of some kinds which in their completed state are partly American and partly foreign. Among these are toy vehicles with horses attached. The vehicles and everything in and about them may be the product of American machinery, while the horse standing between the shafts may be from Germany.

The separation of tin and wolfram ore has been successfully accomplished by means of the Wetherill magnetic concentrator, says the Iron and Coal Trades Review. The ore upon which the experiments were made was from Spain, and consisted of cassiterite contaminated by wolframite. Wolfram in tin ore is a very objectionable element, and ordinarily its elimination involves a tedious and unsatisfactory process. Simple mechanical separation is impossible, since the specific gravity of wolframite is very similar to that of cassiterite. With the Wetherill machine, however, a nearly perfect separation was effected. The wolframite, besides being removed from the tin ore, was converted into a clean, marketable product for ferro-tungsten manufacture. The ores of which wolfram was the bane are no longer very important sources of tin supply, and the Bohemian and Saxon mines which furnish a good deal of wolframite have comparatively little cassiterite associated with them, so that the scope of the Wetherill machine is limited to the inferior Spanish ores, which were the subject of the experiments.

According to Dingler's Polytechnisches Journal, July 9, the question of carborundum versus emery is at present occupying much attention in Europe, says the Engineering and Mining Journal. In emery the abrasive material is crystallized aluminum oxide; in carborundum it is carbide of silicon. Although carborundum is much harder, its crystalline structure is less favorable for grinding than is emery. The crystals of carborundum are long and narrow, with few cutting edges and smooth faces, while emery crystals are nearly cubical and have rough surfaces. Perhaps the greater hardness of carborundum is offset by the better cutting properties of the emery. This is also indicated by the difficulty in keeping carborundum wheels from glazing when too much slag is used in making them. The author of the paper quoted concludes that emery has the advantage over carborundum for grinding or polishing purposes in all cases except where the finest grades are used. For the latter, carborundum seems to be the better.

The Chemiker Zeitung in a recent issue says that in aluminum castings a distinction must be drawn between castings which are practically finished on leaving the mould and castings which are subsequently subjected to a forging or rolling process. The difficulty of producing sound aluminum castings lies in the great contraction of the metal on cooling. This difficulty can be overcome by adding phosphorus to the molten metal, in the proportion of about one gramme to one kilogramme. Thoroughly sound castings are obtained in this manner, but they are rather brittle, and therefore unfit for rolling purposes. Castings suitable for the last named process are obtained by pouring some rape oil upon the surface of the metal, which is fused in iron crucibles. When all the oil is burnt off, the metal is run in the hot iron moulds, and as soon as the contraction begins more metal is added. The ingots obtained in this way are excellent for rolling, forging or wire drawing purposes. Aluminum fused in graphite crucibles always has a tendency to crack in the rolling or forging, the more so the oftener it has undergone the process of melting in this kind of crucible. This appears to be due to the fact that aluminum takes up silicon from the crucible.

EXPERIENCES IN THE ARCTIC SEAS.

Frederick G. Jackson, the leader of the Jackson-Harmsworth polar expedition, has given, in a recent issue of the London Graphic, an interesting account of his experiences in Arctic exploration and describes as follows how he happened to make his first voyage to the polar regions:

It was in the winter of 1887, while in the Southern States of America, that I received a cablegram from a friend, who, being aware of my desires, told me that if I could be ready to go, and in Peterhead within three weeks, a passage had been offered to me in a whaler leaving that port in the first week of March. In three days I had settled up my affairs and left on the first stage of my journey toward the north. The voyage I then embarked upon in the good ship Eric, under the able command of Captain Alec Gray, in some respects changed my preconceived notions of the world within the Arctic circle and enlarged my ideas, but without reducing my enthusiasm in the smallest degree.

In 1892 I drew up and made public the plans upon which my recent expedition was based, and with the object of testing my equipment and obtaining some practical experience of sledging and camp life during an Arctic winter, in the summer of 1893 I embarked upon one of the vessels of the Yenesei expedition and was landed with my stores and sledges at the Yugor Straits. Here I was able, in the company of two Samoyads, to map in and explore the island of Waigatz, which is of special interest from being the holy island of these remarkable northern people. To certain sacred spots these Samoyads, from the whole of Northern Siberia and Russia, make pilgrimages, traveling frequently many thousands of miles with this object, and taking sometimes months on the journey. Returning south, I then passed through and mapped the Bolshaia Zemelskija Tundra country, having engaged Samoyads and reindeer for the purpose, and was able to put to severe tests the various parts of my equipment which I intended to use on my Franz Josef Land expedition.

On this journey, after reaching comparative civilization, I fell in with and experienced the great value of the hardy northern Russian horses that I then determined to make use of on that expedition, and which have since fully justified my most sanguine expectations and have done us such good service. On reaching the vice-consulate at Archangel I there found Her Majesty's representative, Mr. Cooke, who gave me a most hearty reception and handed me a cablegram requesting me to return to England with all speed, as the money necessary for my expedition to Franz Josef Land had been found by Mr. Harmsworth, who had even requested Mr. Cooke to dispatch a small expedition in the direction of Khabarova to look for me. This, I felt, was a truly satisfactory result of my journey.

I wished, however, instead of returning via Petersburg, the shortest route, to go round the White Sea and through Lapland, with the object of making further inquiries, of gaining more experience of reindeer, and of studying the clothing and equipment of the Lapps. This I satisfactorily accomplished, and the results, I felt, quite justified the time expended upon this second portion of my long sledge journey.

The next five months were occupied in a great scramble to get everything ready for the expedition to Franz Josef Land. Hurry and bustle was the order of the day, but with very few things in an incomplete condition we sailed in the steam yacht Windward for Franz Josef Land on July 11, 1894. At Archangel we called for a log house we had made and erected with numbered joints to facilitate our again building it in Franz Josef Land. Here we also took on board our four ponies and the bulk of our furs. Our reception by the governor and officials was warm and hospitable in the extreme, and we left the last of civilization behind us carrying pleasant remembrances with us. The next point we made for was Khabarova, where the previous year I had spent some time, and here we took on board thirty dogs brought from the neighborhood of the Ob River for our expedition, and after obtaining a supply of reindeer meat, we steamed north for Franz Josef Land, and our real difficulties began. How we at last got through the icy barrier on September 7, erected our living and store houses and landed our goods upon Cape Flora, and the ship became frozen in for the winter, has already been told.

The following spring, as soon as daylight returned, we began pushing forward toward the north our food depots, in accordance with my plans. In this we were aided enormously by the small horses which we had brought forward with us from Archangel for the purpose, and by the beginning of May we reached latitude 81 deg. 20 min. N., established four food depots at suitable distances apart, and had conveyed north two boats for future use, in addition to making many important geographical discoveries and collections of all kinds. Open water then absolutely stopped our advance, and we were obliged to return to Cape Flora with all speed to avoid losing our ponies owing to the early break up of the ice.

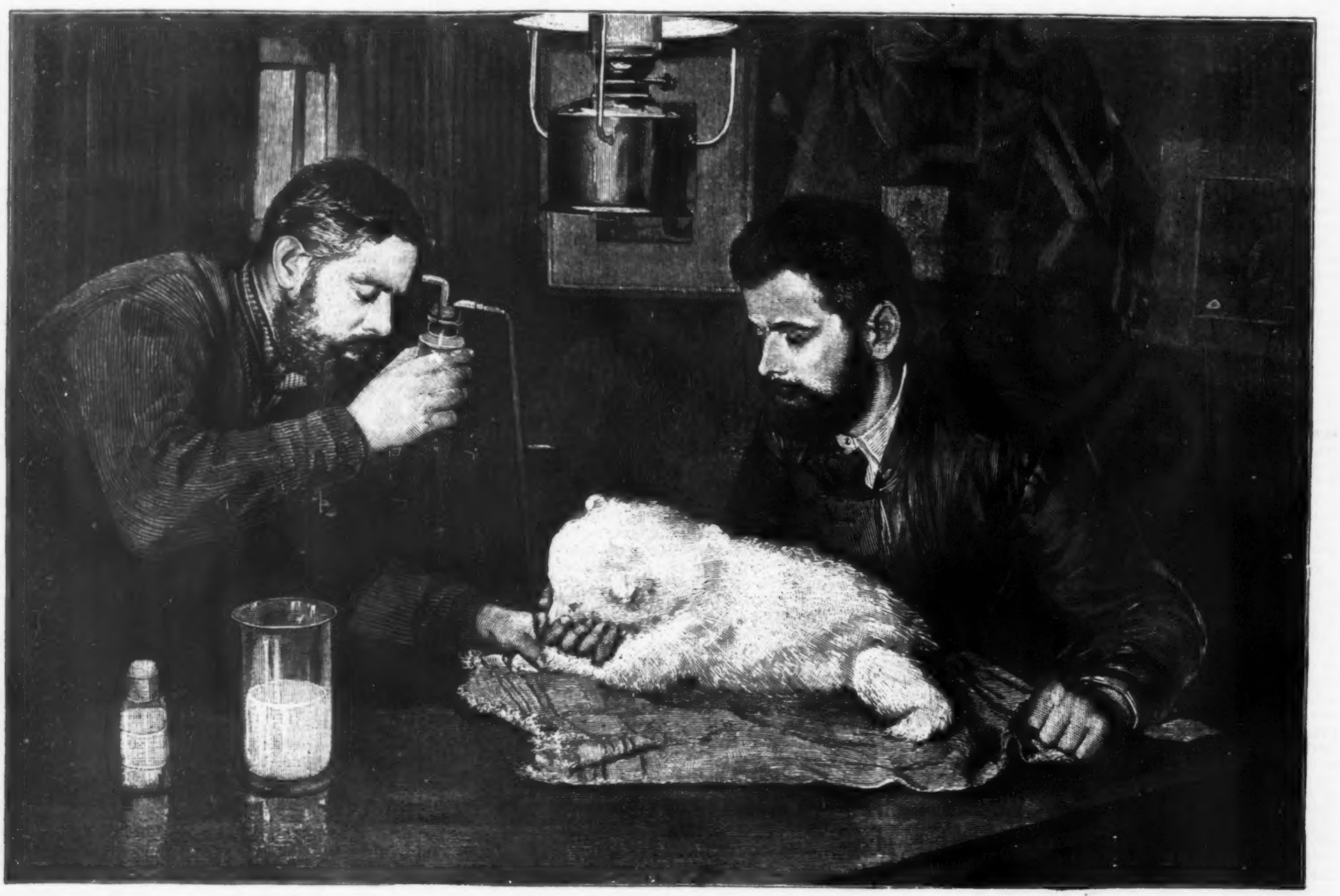
Just prior to our leaving on this journey, a very heavy gale of wind broke up the ice around the ship, and placed her in some peril for a time. A boat lying alongside was swept away, and various other damage was done. As this now left the ship short of boats all hands were set to work to dig two, which I had reserved for the use of the land party, out of the deep snow drifts in which they were buried, and one was taken on board the ship. Directly after the Windward left us in July, we departed on a boat journey along the southwestern coast, and succeeded in adding to Mr. Leigh Smith's discoveries in that direction.

The following winter was passed as comfortably and busily as the previous one and with an equal freedom from illness, and early in the next spring we again started with our sledges north. It was on this journey that my conviction that Franz Josef Land, so far from being a large continental mass as was generally supposed, was in reality but an archipelago of comparatively small islands was confirmed. Open water again met us in the attempt to pass our highest northern latitude of the previous year, but, fortunately, we were able to turn our hands to other geographical work by confirming and adding to that done by us then. The following summer we were fully occupied with scientific work of all kinds, and in the middle of June we met with Nansen and Johansen on their way to the south, having made their wonderful and plucky sledge journey from the farthest north. Never in my life did I experience such keen pleasure as when I was able to welcome these two wanderers to Elmwood and could bid them cast aside their sledges, "kayaks" and "ski," and take their well earned rest. The following winter we were still busier, if possible, than the two that had gone before. New tents, new traces, another canoe, and a thousand and one things had to be attended to. Our absolutely good health still continued, thanks to our doctor's good care of us, and to the ready manner in which the necessary health regulations were complied with by one and all.

On hearing from Dr. Nansen of the non-existence of land to the north, coupled with my own experiences, I decided on completing the map of Franz Josef Land before trying to reach north over the moving pack, and with this object Mr. Armitage and I proceeded up the western shores of the British Channel, of which I completed the mapping, and after a rather tiresome journey of two months, on which, owing to the severe weather, we lost nearly all our draught animals, we succeeded in completing the whole of the western and northwestern shores of Franz Josef Land, and in settling, in my opinion, the for so long vexed question of Gillis Land.

Evia House, on Bell Island, was the scene of a very pleasant little meeting as we neared home. The doctor, having got anxious, owing to our prolonged absence, accompanied by Messrs. Bruce and Wilton, started with a sledge load of provisions to look for us toward the west, but they had only gone ten miles when, on coming up to the hut on Bell Island, they found us encamped inside it.

We remained for ten days at Cape Flora to refit, and Mr. Armitage and I again left with a team of eight rather weak dogs, as I had now hardly any serviceable animals to go east. After doing very well indeed at the outset, when in the neighborhood of Brady Island our sledge broke through the very thin ice, and as we lost all our provisions except a little food put out for lunch, and the ice proving weak in every direction, there was nothing for it but to return. Our chief festivals at Elmwood were Christmas Day, New Year's Day, and birthdays, more especially that of the Queen, when the large jack was run to the head of the flagstaff, and we drank Her Majesty's health in the wine which we kept for such occasions.



FEEDING AN INFANT POLAR BEAR—JACKSON-HARMSWORTH POLAR EXPEDITION.

The post office is laying an underground telegraph cable from London to Birmingham, one of the main reasons of their adopting a long underground trunk line being the difficulty in finding overhead routes. Any additions to the present telephonic trunk lines will of course be made above ground, so that it has been deemed advisable to make use of cable for the supplementary telegraph lines which are now required. The cable contains seventy-six conductors laid up in nineteen fours, each conductor weighing 150 lb. per mile. The sets of four conductors are separated by a cross shaped paper core, being held in place by a single lapping of paper, and the nineteen strand is again surrounded by a lapping of broad paper strip. Both these papers are laid on "half-lap," so that each lapping is equivalent to two thicknesses of paper. The whole is contained in a thick lead covering. Work has been begun at Watford, and about nine miles of cable have been laid on each side of the town. The cables are, says the Electrician, drawn into 3 in. cast iron pipes, 30 miles of piping having already been put down. It is intended to use the dry air system to keep up the ventilation of the line.

THE "HEAVY WEIGHTS" COMPETITION OF THE AUTOMOBILE CLUB.

Despite the pessimistic predictions of some, the competition of "heavy weight" vehicles (for so they have been styled), which has just taken place (after beginning on the 1st of August and continuing six days), has proved a genuine success for French industry. The minister of war appointed a committee to follow its operations, and several illustrious foreigners came to Paris to be witnesses of it.

This international competition was open to all mechanical vehicles, arranged with a view to the following service:

(1) The carriage of passengers, the vehicles accommodating at least 10 persons and 660 pounds of baggage; and (2) the carriage of freight, and the simultaneous carriage of passengers and freight, with a minimum weight of one ton.

Three itineraries had been selected, having gradients reaching 2 inches to the foot. The carriages started from and returned to Place d'Armes, at Versailles.

The three itineraries were as follows:

A.—St. Cyr, Villepreaux, Noisy-le-roi, Roquencourt, Garches, Saint Cloud, Point-du-Jour, Sèvres, Viroflay and Versailles—say 24·5 miles, 6¼ of which were paved roads, with two refreshment stations.

B.—Ville d'Avray, Montretout, Suresnes, Porte-Maillot, Rueil, Saint Germain, Marly-le-Roy, Roquencourt and Versailles—say 27·5 miles, 3¼ of which were paved roads, with two refreshment stations.

C.—Vanmurier, Dampierre, Cernay-la-Ville, Gif, Palaiseau, Jouy-en-Josas and Versailles—say 39½ miles, of which 6½ were paved roads, with four refreshment stations.

Each competing vehicle had to pass over each route twice at a speed that was fixed in advance, so that the obstructing of the roads should be reduced to a minimum. The entire journey to be made was thus 183½ miles, 33 of which were over paved roads. One or more judges upon each carriage noted all the important data, incidents or accidents, etc.

We have no intention of giving the details of the competition in this place (for the report that the Automobile Club is preparing will alone be able to teach us as to the official figures taken), but shall be content to calculate the daily total mean speed of each vehicle. The results, of course, are merely approximate, but they nevertheless give indications that are sufficiently practical. This said, we shall pass very rapidly in review the principal types of carriages that competed, in classifying them in three categories: (1) The omnibuses of Messrs. De Dion-Bouton, Panhard, Scotte and Weidknecht; (2) the trains and pleasure cars of Messrs. De Dion-Bouton, Le Blant, and the Maison Parisienne and Scotte; (3) the freight traction engines of Messrs. Dietrich & Scotte.

The De Dion-Bouton Omnibus (Fig. 4).—This carries 16 passengers and their baggage, say 1,050 pounds, and its motor is of 25 horse power. In this vehicle, the builders have employed those parts that have already been put to the test in their steam brakes, etc. (boiler, engine, direct transmission to the wheels, etc.) The engine is placed under the carriage properly so called, and actuates the hind wheels. In front, above the steering train, is placed the boiler, with the conductor and the fireman. The speed upon a level is capable of reaching 10 miles an hour. In reality, the mean speeds (all stoppages included) were: In itinerary A, 7 and 6 miles an hour; in itinerary B, 5½ and 8 miles an hour; and in itinerary C, 8¼ and 5½ miles an hour.

The Panhard Omnibus (Fig. 6).—This carries 10 passengers and 180 pounds of baggage. It is provided with two coupled Daimler-Phenix vertical gasoline motors of 6 horse power, so that in reality it is a 4 cylinder, 12 horse power motor, which is placed under the front seat, and actuates the hind wheels. The transmission is effected through gearings and chains with four differential speeds.

The weight, in running order, is 7,920 pounds. The speed on a level reaches 10 miles an hour. In reality, the mean speeds (all stoppages included) were: Upon itinerary A, 6 and 5 miles an hour; upon itinerary B, 4¼ and 5 miles an hour; and upon itinerary C, 5½ and 4½ miles an hour.

The Scotte Omnibus (Fig. 1).—This carries 12 passengers and their baggage. The motor, which is of 16 horse power, is placed in front, above the steering train. The transmission is by gearings and chains, with two different speeds. The driving wheels are in the rear. The weight, in running order, is four tons. The speed on a level is 9 miles an hour. The mean speeds (all stoppages included) were: Upon itinerary A, 4¼ and 4¼ miles an hour; upon itinerary B, 6 and 4¾ miles an hour; and upon itinerary C, 4¼ and 4¾ miles an hour.

The Weidknecht Omnibus.—This vehicle is of the General Omnibus Company's type of 30 seats. The steam motor, of 34 horse power, acts through chains upon the large front wheels, the steering wheels being behind. The weight in running order is 6 tons. This vehicle was obliged to stop at the end of the third day, in consequence of an accident to the frame. Its mean speed was 3, 3½ and 3¾ miles an hour upon the three itineraries.

The De Dion-Bouton Traction Engine (Fig. 5).—This hauls a long pleasure car, and has the same mechanical arrangements as the omnibus. It has a seating capacity for 32 passengers without baggage. The mean speeds (all stoppages included) were: Upon itinerary A, 5½ miles an hour; upon itinerary B, 5 and 5 miles an hour; and upon itinerary C, 4½ and 3½ miles an hour.

Let us say, apropos of this latter figure, that, in consequence of an accident to a connecting rod, the vehicle had to make the second half of its trip with a single engine.

The Le Blant Brake.—This is a carriage that is now old, since it was constructed as far back as 1892, and took a prize in 1894, at the Paris-Rouen competition.

It has accommodations for 12 passengers and 1,100 pounds of baggage. The steam motor is of 12 horse power. The vehicle was put out of service on the very first day, in consequence of a fire occasioned by the smoke stack.

The Maison Parisienne Pleasure Car.—This has accommodations for [illegible]2 passengers. It is provided with a 9 horse power horizontal gasoline motor of the Benz type. The transmission is by belts. Its weight, in running order, is 5,000 pounds. It was run with but half a load, which will throw it out of the competition. Under these conditions it made the average speeds of 5, 6½ and even 8 miles an hour.

The Scotte Train (Fig. 2).—This consists of a motive vehicle, with a seating capacity for 14 persons, hauling a carriage with accommodations for 18 persons and 2,100 pounds of baggage. It is provided with a 16 horse power steam motor having the same mechanical arrangements as those of the omnibus. The mean speed on a level is from 7 to 8½ miles an hour. The actual speeds obtained were: Upon itinerary A, 4¼ and 4½ miles an hour; upon itinerary B, 5½ and 4¾ miles an hour; and upon itinerary C, 4¼ and 4¾ miles an hour. The running was very regular and sure. Besides, let

Fig. 1.—GENERAL VIEW OF THE SCOTTE OMNIBUS.

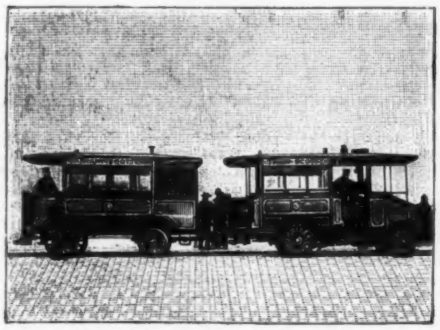


Fig. 2.—SCOTTE PASSENGER TRAIN.

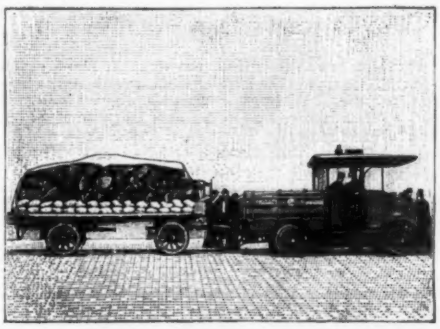


Fig. 3.—SCOTTE FREIGHT TRAIN.

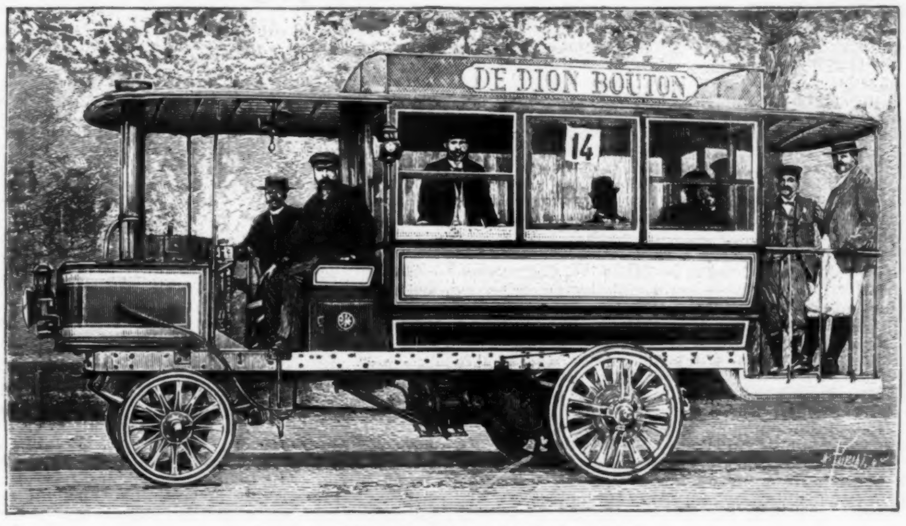


Fig. 4.—DE DION-BOUTON OMNIBUS.

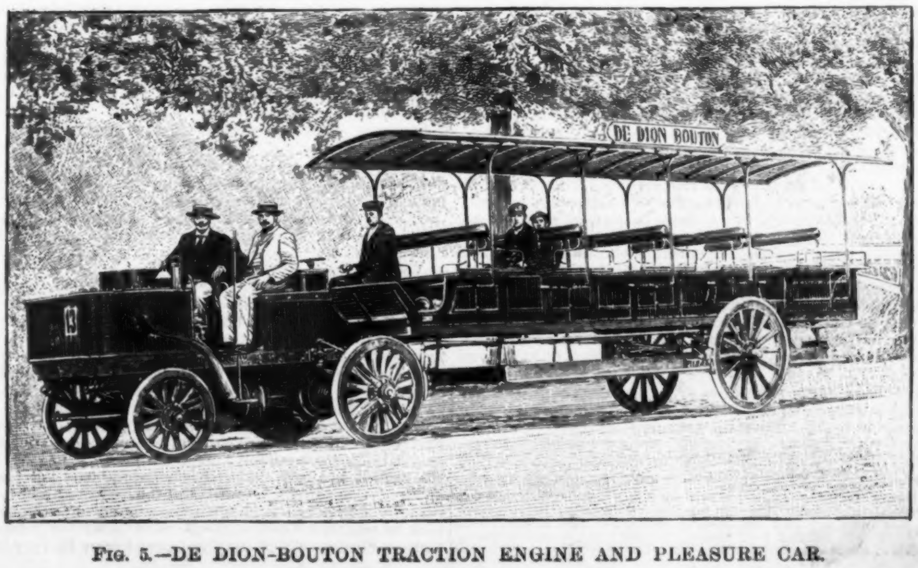


Fig. 5.—DE DION-BOUTON TRACTION ENGINE AND PLEASURE CAR.

us recall the fact that an analogous train has been running for a few months past for the public service between Courbevoie and Colombes.

Dietrich's Freight Truck.—This is provided with a 7 horse power gasoline motor, and carries a load of 2,640 pounds. The average speeds (all stoppages included) varied from 4 to 5¾ miles an hour.

The Scotte Freight Train (Fig. 3).—This consists of a traction engine that carries 2½ tons and of a 9 ton flat car, say 12 tons in all, in running order. The mechanical arrangements are analogous to those of the omnibus and passenger train. The speed on a level is from 4¾ to 6 miles an hour. The mean speeds obtained (stoppages included) varied from 3 to 3¾ miles an hour.

We shall draw no conclusions from the figures that we have just given, having desired merely to present the principal types of the vehicles that competed. After the official report of the Automobile Club of France has been made public we shall be able to appreciate the relative value of the different systems. Let us say merely that the Versailles competition showed that several carriages were capable of a normal and assured operation, and that among these must be mentioned the systems of Scotte, De Dion-Bouton and Panhard and Dietrich.—La Nature.

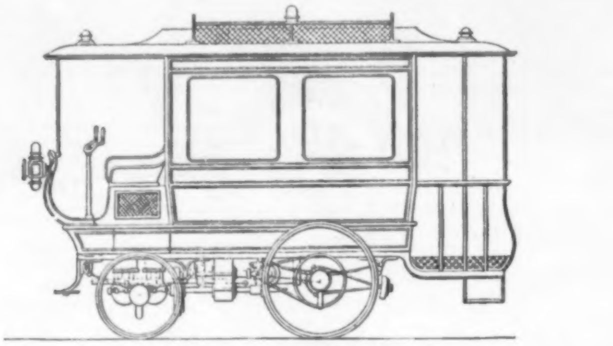


Fig. 6.—PANHARD OMNIBUS.

[Continued from Supplement, No. 1135, page 18148.]

THE SPREAD OF LAND SPECIES BY THE AGENCY OF MAN; WITH ESPECIAL REFERENCE TO INSECTS.*

By Leland O. Howard, Ph.D.

There remains one more source of accidental introductions, and it is one which has been reasonably prolific as regards insects on several occasions. I refer to international expositions, which are now becoming of almost annual occurrence. At the Centennial Exposition at Philadelphia, in 1876, the insects occurring in the exhibits, especially of foreign grains, received some study by Dr. Riley, who published a short note in the Proceedings of the St. Louis Academy of Science for October 2, 1876. A special committee of the Philadelphia Academy, consisting of Drs. Horn, Leidy and Le Conte, also prepared and published a report at this time, but none but well known and cosmopolitan forms were found. I am not familiar with the results of any studies of a similar nature made at the Paris Exposition Universelle of 1889, but have seen the title of a paper by M. Decaux which reads "Etudes sur les insectes nuisibles receuillis à l'Exposition Universelle," Paris, 1890, which, however, I have not been able to consult.

In 1893, however, careful observations were made at the World's Fair at Chicago by Mr. F. H. Chittenden, the results of which were published by Dr. Riley in Volume VI of Insect Life. Insects to the number of 101 species were found in grain and other stored vegetable products. Seven species were found affecting animal products and 13 wood-feeding species were found in the forestry building. The interesting and significant fact is mentioned in this article that there was an exchange of seed samples between the representatives of different countries, which would of course greatly facilitate the spread of seed-inhabiting insects, and it was further shown that thousands of samples were taken away from open bags by visitors from all parts of this country and probably from other parts of the world. Moreover, at the close of the Exposition the sheaves of cereals used in the decorations were taken away by armfuls by visitors. After summarizing the habits and countries of origin of the different species, however, Dr. Riley expressed the opinion that no dangerous importations were made at this time. It seems altogether likely, however, that Phyllotreta armoraciæ, a European species which has established itself in northern Illinois, Iowa and Wisconsin since 1893, and which was found by Mr. Chittenden in that year in vacant lots near the exposition grounds, was an exposition importation. Moreover, an interesting Calandrid of the genus Tranes, the species of which are all Australian, has established itself injuriously in greenhouses in St. Louis as the result of the introduction of two plants of Zamia spiralis which were bought at the World's Fair. With these instances in mind we cannot but admit that other species heretofore overlooked probably escaped and have become acclimatized as the result of this exposition, and that such occasions, occurring as they do more and more frequently and drawing constantly increasing material from all parts of the world, will, unless precautionary measures are instituted, afford more and more frequent opportunities of a very favorable kind for the spread of injurious species.†

We have thus seen how great the opportunities are under our modern conditions for the transportation, in proper condition for establishment, of insects of many groups, and from this point of view it seems strange, in view of the very numerous importations, that more species do not become acclimatized even in North America, where, perhaps, we reach the greatest possibilities in this direction. Our most intimate commercial relations are with the great faunal region most like our own, and these relations are rapidly growing both with Europe on the east and with Asia on the west, although our Asiatic importations are more abundant from the Oriental region than the Palearctic, and from the Oriental we are not so likely to receive species which will acclimatize themselves. We have already pointed out that the faunistic relations with the Coleoptera (and undoubtedly with other groups) are least marked between the north temperate and south temperate regions, and this distinction is never likely to be disturbed by imported species on account of the diametrically opposed seasons. A species starting from Argentina in the height of summer will reach the United States in the dead of winter at a time least likely to favor its acclimatization. This point was first suggested by my colleague, Mr. E. A. Schwarz, in his paper entitled "The Coleoptera Common to North America and Other Countries." (Proc. Entom. Soc. Wash., I, 182-194.)

It appears from what we have shown that very many species are constantly being imported which do not become acclimatized. Many of the European species which we should most expect to take hold in this country have not done so, while with others it is the unexpected which has happened. As Osten Sacken says, speaking of the Diptera: "Importation will not occur for centuries in cases where it might be expected from day to day; and, again, it will sometimes take place under circumstances most improbable, and, à priori, impossible to foresee." (Proc. Entom. Soc. Lond., 1894, p. 489.)

Why should the well known Pieris rapæ have made its appearance in this country and spread far and wide, while the equally common and injurious Pieris brassicæ and P. napi have never been found here? Why should Phytonomus punctatus have flourished with us when it is hardly known as a clover enemy in Europe, and when the congeneric Phytonomus meles, of Europe, has never been found here? Why should Coleophora laricella have established itself here and none of the other European Coleophoras (some of them of much greater distribution and hibernating in cases of protective coloration and shape, and attached to plants) have acclimated themselves among us? Why should Calliphora vomitoria, Crytoneura stabulans and Stomoxys calcitrans have been brought over at an early date and flourished to excess in America and many other countries, while Sarcophaga carnaria is unknown in any of them?

Mr. Schwarz has phrased it: "We stand here before some great unknown factor, viz., the individual character and inmost nature of the species which governs the introduction or non-introduction of each species—a factor which is variable according to each species . . . ." But there is no reason why a mystery need be made of this condition. In a word, it is the capacity of the individual species to accommodate itself to a more or less novel environment. Nowhere in the whole animal kingdom do we find the natural environment more complicated than with insects. Conditions are frequently dependent upon conditions in an almost endless chain. The phenomena of fatal parasitism are of vital importance as determining the abundance of the species and are curiously complicated. I have recently proved the existence of several fatal tertiary parasites and the probable existence of quaternary parasites with Orgyia leucostigma in Washington. Upon the condition of this chain of interdependencies rests the welfare of the primary host. If adverse conditions affect the quaternary parasite, the primary host suffers, for the tertiary parasites increase and kill off the secondary parasites, allowing an increase of the primary parasites which kill off the Orgyia. The famous instance of Darwin in which he showed that in a measure cats are responsible for the production of clover seed in England through the interrelations of cats, field mice and bumble bees, is paralleled and outdone again and again among insects. Further, in no group of animals are the characteristics termed special protective resemblance and special aggressive resemblance, to say nothing of protective and aggressive mimicry, so well marked and so important in the life of the species as with the insects. It is upon the degree of simplicity of its life—the degree of simplicity of its normal environment as a whole—that the capacity of a species for transportation and acclimatization, even into a parallel life zone, depends.

Nevertheless, I am fully convinced that very many more species will stand transportation from the Palearctic to the Nearctic, from the Australian to the Oriental and the Neotropical regions, than would be supposed from a consideration of these points and from a knowledge of the comparatively few forms which have as yet been transported and acclimatized. Aside from the forms brought in with their food and thus under the most favorable conditions for establishment, it is only by a lucky chance with the average accidental insect immigrant that it finds conditions for reproduction—a chance which may not occur once in very many times. Osten Sacken has pointed out that Eristalis tenax must have been brought here many times during four hundred years before it succeeded in establishing itself. Undoubtedly many of these immigrants die upon our wharves when a lucky chance like crawling upon the clothes of a person and thus being carried out into the country might have resulted in the establishment of the species. Given the most favorable conditions, and many species will be able not only to accommodate themselves to a new environment, but certain of them will thrive better in the new than in the old. The effort to transport beneficial species from the Australian region and acclimatize them in the Nearctic region seemed a rash and unprofitable experiment on its face, and I confess that I for one had little hope of its success, yet it was successful with several species and transcendently successful with one.

Much has been written of late about the success of the work in the introduction of beneficial insects by Mr. Albert Koebele into Hawaii, under the auspices of the Hawaiian government. Some of the introductions seem, without doubt, to have been strikingly successful. Mr. R. E. C. Perkins has reported at some length upon this success and, in commenting upon its reasons, says:

"It becomes natural to ask why the success of the imported beneficial insects has been so pronounced here, while in other countries it has been attained in a comparatively small measure. The reason, I think, is sufficiently obvious. The same causes which have led to the rapid spread and excessive multiplication of injurious introductions have operated equally on the beneficial ones that prey upon them. The remote position of the islands, and the consequently limited fauna, giving free scope for increase to new arrivals, the general absence of creatures injurious to the introduced beneficial species, and the equability of the climate, allowing of almost continual breeding, may well afford results which could hardly be attained elsewhere on the globe. The keen struggle for existence of continental lands is comparatively non-existent, and, so far as it exists, is rather brought about by the introduced fauna than by the native one."

Mr. Perkins' reasons are all good, but he has not mentioned one prime reason of success, and that is that the most successful of the imported species have come from another portion of the same great faunal region, while others have been received from the region most closely allied, viz., the Oriental.

Wallace took the view that the effectual migration of insects is, perhaps, more than with any other class of animals, limited by organic and physical conditions. "The vegetation," he says, "the soil, the temperature and the supply of moisture must all be suited to their habits and economy, while they require an immunity from enemies of various kinds, which immigrants to a new country seldom obtain."

There is much truth in this statement, but it must be remarked that, in practical experience, immunity from enemies of various kinds is what insect immigrants find, not what they leave behind them. It takes some time before they weave into a new chain of organism preying upon organism. Our insect importations from abroad, when they are of economic importance—and those from Europe are very likely to be of such importance—leave their old insect enemies behind them and frequently are not readily attacked by native ones. These last accommodate themselves to the new comer in time, but for a while he enjoys comparative immunity. The rapid multiplication and spread of Pieris rapæ, of Hæmatobia serrata, of Phytonomus punctatus, of Porthetria dispar, of Anthonomus grandis, of Icerya purchasi and many others may probably be principally laid to this cause.

I should be remiss did I not refer to another aspect of the accidental introduction of species, viz., that it not only adds species to a native fauna, but also that it often causes the disappearance of native forms. Since the establishment, within our boundaries, of Pieris rapæ, our native Pontia oleracea has almost entirely disappeared in localities in which it formerly abounded, and in some sections has entirely disappeared. Since Doryphora 10-lineata came east and multiplied upon the cultivated potato in such prodigious numbers, the formerly common eastern Doryphora juncta has become a rare species. Walsh pointed out thirty years ago that one effect of the westward spread of the European Mytilaspis pomorum was to cause the gradual local disappearance of the native Chionaspis furfurus. Hubbard has shown that the increase of the imported Mytilaspis citricola in Florida was followed by the decrease of Mytilaspis gloverii, which, though not native, was an earlier importation—a most interesting, and, so far as records go, unique case. Instances might be multiplied which will show that the establishment of foreign species thus often produces at least a dual effect on the character of the fauna as a whole.

In closing it will not be inappropriate to point out that the accidental importation of species is only one of the ways in which the agency of man is altering the character of native faunas, and, that, in spite of its extent, it is really the least of the ways. The influence of civilization is immediately destructive to natural floras and faunas. It is already too late to gain an adequate idea of natural conditions in even recently settled portions of the globe. Wallace has dwelt upon the comparatively scanty and unimportant results to natural history of most of the great scientific voyages of the various civilized governments during the present century, from which it has resulted that "the productions of some of the most frequently visited and most interesting islands on the globe are still very imperfectly known, while their native plants and animals are being yearly exterminated. . . . Such are the Sandwich Islands, Tahiti, the Marquesas, the Philippine Islands and a host of smaller ones; while Bourbon and Mauritius, St. Helena and several others have only been adequately explored after an important portion of their productions has been destroyed by cultivation or the reckless introduction of goats and pigs." ("Island Life," p. 7.)

Elsewhere he shows that the introduction of goats into St. Helena utterly destroyed a whole flora of forest trees, and with them all the insects, mollusca, and perhaps birds dependent upon them. And further, that "cattle will in many districts wholly prevent the growth of trees; and with the trees the numerous insects dependent on those trees, and the birds which

* Paper read before the Zoological Section of the American Association for the Advancement of Science, August, 1897. A portrait of Doctor Howard will be found in the Scientific American of September 25, page 195.

† During the later months of the World's Fair precautionary measures were instituted under Mr. Chittenden's supervision. Much dry food material was fumigated with bisulphide of carbon, and many samples which were very badly infected were burned. At least four new and dangerous species of insects were destroyed in this way.

feed upon the insects, must disappear as well as the small mammalia which feed on the fruits, seeds, leaves or roots." Many local American instances have been brought together by Mr. F. M. Webster in an important paper entitled "Biological Effects of Civilization on the Insect Fauna of Ohio," which comes to me as I write these closing lines.

But the purpose of this address has been to dwell solely upon the question of the spread of species, and I must not touch upon other topics, however closely akin. It seems to me that the practical point to which we must come, after summarizing all that has been shown, is that since so many species have been imported by pure accident, and have succeeded perfectly in becoming acclimatized, may not much be accomplished by wisely planned and carefully guarded introductions? The somewhat haphazard but none the less important and skillful work of Albert Koebele, first for the United States government, afterward for the State of California, and now for the Hawaiian government, is certainly an indication, taken in connection with what we have shown, that thorough experimental work with predaceous and parasitic insects promises, in especial cases, results of possibly very great value.

We wish no more destructive birds like the English sparrow, we have no desire to make an American resident of the Indian mongoos, nor have we any desire to import the Australian flying fox as a pet. Neither do we desire to allow any more European plants to escape from cultivation and emulate the Russian thistle. But there are many absolutely beneficial insects of Palearctic regions which might flourish among us, and whose intentional introduction could not be harmful from any point of view, while they might be of the greatest service.

[Continued from Supplement, No. 1135, page 18149.]

THE BRITISH ASSOCIATION—ADDRESS IN ANTHROPOLOGY.

The address in Section H was delivered by Prof. Sir W. Turner, D. Sc., F.R.S. L. and E., who selected as the subject:

Some Distinctive Characters of Human Structure.

THE EFFECT OF CLOTHES.

One of the requirements of civilization is the wearing of clothes, and fashion frequently prescribes that they should be tight-fitting and calculated to restrict motion in and about the spinal column. In savage races, on the other hand, clothing is often reduced to a minimum, and when worn is so loose and easy as in no way to hamper the movements of the body. The spinal column retains, therefore, in them much more flexibility, and permits the greater measure of freedom in the movements of the trunk which is found in savage man, and has often been referred to by travelers. It used to be considered that the possession of a lumbar convexity in the spinal column was the exclusive privilege of man, and was shared in by no other vertebrate. There can be no doubt that it attains a marked development in the human spine, and, as such, is associated with the erect posture. But the observations of Cunningham on the spinal column of apes, more especially the anthropoid group, made in fresh specimens, in which the intervertebral disks were in place, have proved that in the chimpanzee the lumbar convexity is probably as strongly pronounced as in the adult man. In a chimpanzee, two years old, the development is more advanced than in a child of the same age. The lumbar convexity is established at an earlier age than in the child, for it would seem as if the chimpanzee attained its maturity at a younger period of life than the human being. In the orang the lumbar curve is more feeble than in man and the chimpanzee, and in the specimen described by Cunningham resembled that of a boy six years old. In a fresh specimen of the gibbon, examined by the same anatomist, the lumbar curve was intermediate between the chimpanzee and the orang. Without going into the question whether a lumbar convexity exists in the tailed monkeys, the determination of which with precision is a matter of some difficulty, it must be obvious that the presence of this convexity can no longer be regarded as the exclusive prerogative of man. It undoubtedly forms an important factor in the study of the erect attitude; but in order that man should acquire and be able to retain his distinctive posture, something more is necessary than the possession of a spinal column with a curve in the lumbar region convex forward.

THE THIGH AND LEG.

Our attention should now be directed to the lower limbs, more especially to the two segments of the shaft, which we call thigh and leg. If we look at a quadruped, we see that the thigh is bent on the trunk at the hip joint, and that the leg is bent on the thigh at the knee joint; while the foot forms more or less of an angle with the leg, and the animal walks either on the soles of its feet or on its toes. In the anthropoid apes there is also distinct flexure both of the hip and knee joints, so that the leg and thigh are set at an angle to each other, and the foot is modified, through a special development of the great toe, into an organ of prehension as well as of support. When we turn to the human body, we find that in standing erect the leg and thigh are not set at an angle to each other, but that the leg is in line with and immediately below the thigh, that both hip and knee joints are fully extended, so that the axis of the shaft of the lower limb is practically continuous with the axis of the spine. The foot is set at right angles to the leg, and the sole is in relation to the ground. The vertical axis of the shaft of the lower limb, the extended condition of the hip and knee joints, and the rectangular position of the foot to the leg are, therefore, fundamental to the attainment of the erect attitude of man. As compared with the ape, the shaft of the human thigh bone is not so broad in relation to its length; when standing erect the shaft is somewhat more oblique, it is more convex forward and generally more finely modeled, and it has three almost equal surfaces, the anterior of which is convex. But, further, a strong ridge (linea aspera) extends vertically down its posterior surface, so that a section through the shaft is triangular, with the two anterior angles rounded and the posterior prominent. In the gorilla, chimpanzee, and orang the shaft is flattened from before backward, and the linea aspera is represented by two faint lines, separated from each other by an intermediate narrow area. A section through the shaft approximates to an ellipse. In the gibbon the femur is greatly elongated, and the shaft is smooth and cylindriform. The linear aspera is for the attachment of powerful muscles, which are more closely aggregated in man than in apes, so that the human thigh possesses more graceful contours. In the human femur the shaft is separated from the neck by a strong anterior intertrochanteric ridge, to which is attached the ilio-femoral ligament of the hip joint, which by its strength and tension plays so important a part in keeping the joint extended when the body is erect. In the anthropoid apes this ridge is faint in the gorilla, and scarcely recognizable in the orang, gibbon, and chimpanzee, and the ilio-femoral ligament in them is comparatively feeble.

It may safely, therefore, be inferred that in apes, with their semierect crouching attitude, the ilio-femoral band is not subjected to, or capable of sustaining, the same strain as in man. The head of the thigh bone is also distinctive. In the apes the surface covered by cartilage is approximately a sphere, and is considerably more than a hemisphere. It is sharply differentiated from the neck by a definite boundary, and it has a mushroomlike shape. In man the major part of the head is also approximately a sphere; but, in addition, there is an extension outward of the articular area on the anterior surface and upper border of the neck of the bone. The form of this extended area differs from the spherical shape of the head in general. The curvature of a normal section of its surface has a much larger radius than the curvature of a normal section of the head, near the attachment of the ligamentum teres.

THE HUMAN FOOT.

I shall now proceed to the examination of the human foot (pes), and in order to bring out more clearly its primary use as an organ of support and progression, I shall contrast it with the human hand (manus) and with the manus and pes in apes. In man, while standing erect, the arched sole of the foot is directed to the ground, and rests behind on the heel and in front on pads, placed below and in line with the metatarso-phalangeal joints, the most important of which is below the joint associated with the great toe. It is, therefore, a plantigrade foot. The great toe (hallux) lies parallel to the other toes, and from its size and restricted movements gives stability to the foot. The ape's foot agrees with that of man in possessing similar bones and almost similar soft parts; but it differs materially as to the uses to which it can be put. Some apes can undoubtedly place the sole upon the ground, and in this position use the foot both for support and progression, though the orang, and to some extent other anthropoid apes, rest frequently upon the outer edge of the foot. But, in addition, these animals can use the foot as a prehensile organ like the hand. The old anatomist, Tyson, in his description of a young chimpanzee, spoke of the pes as "liker a hand than a foot" and introduced the term "quadrumanous," four-handed, to designate this character. This term was adopted by Cuvier, and applied by him to apes generally, and has long been in popular use. The eminent French anatomist was, however, quite alive to the fact that, though the pes was capable of being used as a hand, yet it was morphologically a foot, so that the term was employed by him to express a physiological character. In the ape the great toe, instead of being parallel to the other toes as in man, is set at an angle to them, not unlike the relation which the thumb (pollex) bears to the fingers in the human hand. It is able, therefore, to throw the hallux across the surface of the sole in the prehensile movement of opposition, as it can at the same time bend the other toes toward the sole. It also has the power of encircling an object more or less completely with them. By the joint action of all the toes a powerful grasping organ is produced, more important even than its hand, in which the thumb is feebly developed. It has sometimes been assumed that the human foot is also a prehensile instrument as well as an organ of support. In a limited sense objects can undoubtedly be grasped by the human toes when bent toward the sole. In savages this power is preserved to an extent which is not possible in civilized man, in whom, owing to the cramping, and only too frequently the distorting influence, exercised by badly-fitting boots and shoes, the proper development of the functional uses of the toes is impeded, and their power of independent movement is often destroyed. If we compare the anatomical structure of the human foot with that of the foot of the ape, though the bones, joints, and muscles are essentially the same in both, important differences in arrangement may be easily recognized, the value of which will be better appreciated by first glancing at the thumb. Both in man and apes the thumb is not tied to the index digit by an intermediate ligament, which, under the name of "transverse metacarpal," binds all the fingers together, and restricts their separation from each other in the transverse plane of the hand. The great toe of the ape, similarly, is not tied to the second toe by a "transverse metatarsal ligament," such as connects together and restricts the movements of its four outer toes in the transverse plane of the foot. The hallux of the ape is, therefore, set free. It can, like the thumb of man and ape, be thrown into the position of opposition and be used as a prehensile digit. Very different is the case in the human foot, in which the hallux is tied to the second toe by a continuation of the same transverse metatarsal ligament which ties the smaller toes together. Hence it is impossible to oppose the great toe to the surface of the sole in the way in which the thumb can be used, and the movements of the digit in the transverse plane of the foot are also greatly restricted.

THE HEAD.

The head, situated at the summit of the spine, holds a commanding position. Owing to the joints for articulation with the atlas vertebra being placed on the under surface of the skull, and not at the back of the head, and to the great reduction in the size of the jaws, as compared with apes and quadrupeds generally, the head is balanced on the top of the spine. The ligaments supporting it and connected with it are comparatively feeble, and do not require for their attachment strong, bony ridges on the skull, or massive projecting processes in the spine, such as one finds in apes and many other mammals. The head with the atlas vertebra can be rotated about the axis vertebra by appropriate muscles. The face looks to the front, the axis of vision is horizontal, and the eye sweeps the horizon with comparatively slight muscular effort. The cranial cavity, with its contained brain, is of absolutely greater volume in man than in any other vertebrate, except in the elephant and in the large whales, in which the huge mass of the body demands the great sensory-motor centers in the brain to be of large size. Relatively also to the mass and weight of the body, the brain in man may be said to be in general heavier than the brains of the lower vertebrates, though it has been stated that some small birds and mammals are exceptions to this rule. We have abundant evidence of the weight of the brain in Europeans, in whom several thousand brains have been tested. In the men, the average brain weight is from 49 to 50 oz. (1,390 to 1,418 grm.) In the women, from 44 to 45 oz. (1,248 to 1,283 grm.) The difference in weight is doubtless in part correlated with differences in the mass, weight and stature of the body in the two sexes, although it seems questionable if the entire difference is capable of this explanation. It is interesting to note that even in new born children the boys have bigger heads and heavier brains than the girls. Dr. Boyd gives the average for the girl infants as 10 oz. and for boys 11·67 oz. A distinction in the brain weight of the two sexes is obviously established, therefore, before the child is born, and is not to be accounted for by the training and educational advantages enjoyed by the male sex being superior to those of the female sex. The brains of a number of men of ability and intellectual distinction have been weighed, and ascertained to be from 55 to 60 oz. In a few exceptional cases, as in the brains of Cuvier and Dr Abercrombie, the weight has been more than 60 oz.; but it should also be stated that brains weighing 60 oz. and upward have occasionally been obtained from persons who had shown no sign of intellectual eminence.

PHRENOLOGY.

The school of phrenologists represented in the first half of the century by Gall, Spurzheim, and George Combe, while recognizing the importance of the size of the brain as a measure of intellectual activity, also attached value to what was called its quality. At that time the inner mechanism of the brain was almost unknown, for the methods had not been discovered by which its minute structure could be determined. It is true that a difference was acknowledged between the cortical gray matter situated on the surface of the hemispheres and the subjacent white matter. Spurzheim had also succeeded in determining the presence of fibers in the white matter of the encephalon, and had, to a slight extent, traced their path. The difference between the smooth surface of the hemispheres of the lower mammals and the convoluted surface of the brain of man and the higher mammals, and the influence which the development of the convolutions exercised in increasing the area of the cortical gray matter, were also known. A most important step in advance was made when, through the investigations of Leuret and Gratiolet, it became clear that the convolutions of the cerebrum, in their mode of arrangement, were not uniform in the orders of mammals which possessed convoluted brains, but that different patterns existed in the orders examined. By his further researches, Gratiolet determined that in the anthropoid apes, notwithstanding their much smaller brains, the same general plan of arrangement existed as in man, though differences occurred in many of the details, and that the key to unlock the complex arrangements in man was to be obtained by the study of the simpler disposition in the apes. These researches have enabled anatomists to localize the convolutions and the fissures which separate them from each other, and to apply to them precise descriptive terms. These investigations were necessarily preliminary to the histological study of the convolutions and to experimental inquiry into their functions. By the employment of the refined histological methods now in use, it has been shown that the gray matter in the cortex of the hemispheres, and in other parts of the brain, is the seat of enormous numbers of nerve cells, and that those in the cortex, while possessing a characteristic pyramidal shape, present many variations in size. Further, that these nerve cells give origin to nerve axial fibers, through which areas in the cortex become connected directly or indirectly, either with other areas in the same hemisphere, with parts of the brain and spinal cord situated below the cerebrum, with the muscular system, or with the skin and other organs of sense. Every nerve cell, with the nerve axial fiber arising from and belonging to it, is now called a neurone, and both brain and spinal cord are built up of tens of thousands of such neurones. It may reasonably be assumed that the larger the brain, the more numerous are the neurones which enter into its constitution. The greater the number of neurones, and the more complete the connections which the several areas have with each other through their axial fibers, the more complex becomes the internal mechanism, and the more perfect the structure of the organ. We may reasonably assume that this perfection of structure finds its highest manifestations in the brain of civilized men. The specialization of the relations and connections of the axial fiber processes of the neurones, at their termination in particular localities, obviously points to functional differences in the cortical and other areas, to which these processes extend. It has now been experimentally demonstrated that the cortex of the cerebrum is not, as M. Flourens conceived, of the same physiological value throughout; but that particular functions are localized in definite areas and convolutions. It speaking of localization of function in the cerebrum, one must not be understood as adopting the theory of Gall, that the mental faculties were definite in their number, that each had its seat in a particular region of the cortex, and that the locus of this region was marked on the surface of the skull and head by a more or less prominent "bump." We have now direct anatomical evidence, based upon differences in the stages of development, that, in addition to the sensory and motor areas in the cortex of the human brain, a third division—the association centers—is to be distinguished. If we compare the cerebrum in man and the apes, we find these convolutions which constitute the motor and sensory centers distinctly marked in both. An ape, like a man, can see, hear, taste, smell, and touch; it also exhibits great muscular activity and variety of movement. It possesses, therefore, similar fundamental centers of

sensation motion, which are situated in areas of the cortex resembling in arrangement and relative position though much smaller in size than the corresponding convolutions in the adult human brain. It is not unlikely, though the subject needs additional research, that the miniature structure of these centers resembles that of man, though, from the comparatively restricted area of gray matter in the ape, the neurones will necessarily be much fewer in number. In the cerebrum of a new born infant, while the motor and sensory convolutions are distinct, the convolutions for the association areas, though present, are comparatively simple, and do not possess as many windings as are to be seen in the brain of a chimpanzee not more than three or four years old. The problem which has now to be solved is the determination of their function. Prolonged investigation into the development and comparative histology of the brain will be necessary before we can reach a sound anatomical basis on which to found satisfactory conclusions.

INSTINCT AND INTELLIGENCE.

We know that an animal is guided by its instincts, through which it provides for its wants and fulfills its place in nature. In man, on the other hand, the instinctive acts are under the influences of the reason and intelligence, and it is possible that the association centers, with the intermediate association fibers which connect them with the sensory and motor centers, may be the mechanism through which man is enabled to control his animal instincts, so far as they are dependent on motion and sensation. The higher we ascend in the scale of humanity, the more perfect does this control become, and the more do the instincts, emotions, passions and appetites become subordinated to the self-conscious principle which regulates our judgments and beliefs. It will, therefore, now be a matter for scientific inquiry to determine, as far as the anatomical conditions will permit, the proportion which the association centers bear to the other centers both in mammals and in man, the period of development of the association fibers, in comparison with that of the motor and sensory fibers in different animals, and, if possible, to obtain a comparison in these respects between the brains of savages and those of men of a high order of intelligence. The capability of erecting the trunk; the power of extending and fixing the hip and knee joints when standing; the stability of the foot; the range and variety of movement of the joints of the upper limb; the balancing of the head on the summit of the spine; the mass and weight of the brain, and the perfection of its internal mechanism, are distinctively human characters. They are the factors concerned in adapting the body of man, under the guidance of reason, intelligence, the sense of responsibility and power of self-control, for the discharge of varied and important duties in relation to himself, his Maker, his fellows, the animal world, and the earth on which he lives.

RESTORATION OF KANSAS MOSASAURS.

By S. W. Williston.

In the present communication are given restorations of the three principal genera of Kansas Mosasaurs, based upon the material now in the University of Kansas Museum. A detailed description of this material is now in preparation to be shortly published as a volume of the University Geological Survey, of which Chancellor Snow is director. At present only the more striking characters of the three forms will be discussed.

The three genera herewith given comprise all the authentic types known from Kansas. In addition, Holosaurus Marsh, Sironectes Cope and Baptosaurus Marsh have been described from or accredited to the Cretaceous of the State. Sironectes is, I believe, a synonym of Platecarpus. It was based upon the presence of the zygosphene in connection with free chevrons. In Platecarpus there is, in most species, a rudimentary zygosphene, and in some it is nearly as large as in some species of Clidastes. It is possible that Holosaurus is a good genus, but specimens of it must be exceedingly rare. The type specimen, now in the Yale Museum, was collected by myself and represents nearly the complete skeleton. Baptosaurus is practically known only from the posterior part of the jaw, described by Merriam. This is very peculiar in having the articular bone reflected upward at the extremity.

The material upon which the restorations here given are based is as follows: Clidastes is restored from a single specimen, complete in all details, save the terminal phalanges of the front paddle and most of those of the hind paddles. The present restoration differs from the one previously published only in the less flattened skull and in the curvature of the digits.

Platecarpus is based chiefly upon one specimen, comprising a nearly complete disarticulated skull and a connected series of vertebræ to beyond the middle of the tail, the sixty-fifth, together with the pectoral and pelvic girdles and most of the bones of the limbs. The arrangement of these bones has been copied, from Marsh, with some changes. The only parts conjectural are the number of long ribs and the number of chevron-caudal vertebræ. Isolated bones and partly connected series of caudal vertebræ are preserved in other specimens, from which there seem to be very slight differences from the corresponding parts of Tylosaurus. The tail has, therefore, been made to correspond with that of Tylosaurus in length.

Tylosaurus is drawn from three specimens, one with the posterior part of the head and the vertebral column complete to the tip, the second with the skull and cervical vertebræ in perfect preservation, the third with the paddles nearly complete, together with the larger part of the vertebræ and ribs. This last specimen is the one of which figures of the paddles and skin were given by me in a recent issue of this journal. All of these specimens agree closely in size and characters, clearly belonging to the same species.

A comparison of these genera, as shown by the restorations, will be of interest. Platecarpus has an intermediate position between Clidastes and Tylosaurus, which represent the extremes of development of the Kansas forms. In Clidastes the thorax is elongate, the tail relatively short and modified into a powerful propelling organ. The limbs are small, the hind ones especially so. The animal throughout is more slender, and the head relatively short, agreeing in this respect more closely with their nearest modern relatives, the species of Varanus. The vertebræ have the firmest and closest articulations, with the interlocking zygosphene best developed of any of the Mosasaurs. The limbs are less flexible, but relatively stronger, as shown by the closely articulating bones and the fully developed carpus and tarsus, and the more pronounced processes for muscular attachment. The movement through the water in this form was more snakelike than in the others, and propulsion was largely by means of the tail.

In Platecarpus we have the same shortened muzzle as in Clidastes, the vertebræ also relatively slender, and the zygosphene imperfectly developed. The paddles are more of the Clidastes type than that of the Tylosaurus, though the carpus and tarsus are less well developed than in the former. The hind paddles are only slightly smaller than the fore ones, and all are powerful propelling organs, far more so than in any other known genus of the group. Altogether, in proportion to its size, Platecarpus was the most powerful and predaceous of the Kansas Mosasaurs. It will be observed that the teeth in this form, while not as numerous as in Clidastes, or as stout as in Tylosaurus, are more effective weapons than in either of these genera, being more elongated, more curved and more pointed. The neural spines do not form as close a series as in Tylosaurus, indicating greater flexibility.

In Tylosaurus we have in some respects the most specialized of the Mosasaurs. The almost wholly cartilaginous carpus and tarsus, the more elongated digits and the greater number of the phalanges are characters brought about by aquatic habits. On the other hand, the hind paddle is actually larger than the front, and the fifth digit has undergone little or no reduction—characters of a more primitive rank. The paddles are more flexible than in either of the other genera, but they are relatively small and not at all strong. The skull is more elongated anteriorly and there is no trace of a zygosphene.

Dr. Dollo has expressed a doubt of the nature of the vertebræ called pygial by Mr. Case and myself in a former publication. He believes that some of them at least are true lumbar vertebræ, as all were previously thought to be. I feel yet more assured that they are basal caudal and have so restored the different genera. In the living lizard, with the sacral synchondrosis, the ilium is directed forward, throwing the symphysis ischii below the sacrum and leaving the outlet of the pelvis unrestricted. In Varanus there are as few as two non-chevron-bearing vertebræ back of the sacrum. More were not needed. In these marine lizards, on the other hand, the shaft of the ilium is directed obliquely forward, bringing the symphysis of the ischii below the fourth or fifth of the vertebræ succeeding the ligamentous attachment. If these or any of them bore chevrons, it will be immediately seen that they would project into the cavity of the pelvis. Not less than six pygal vertebræ are necessary to leave space for the free exit of the cloaca. The ilium must have been in every case attached to the first non-costiferous vertebra.

In these three species the number of vertebræ in the different regions may be given as follows:

	Clidastes.	Platecarpus.	Tylosaurus.
Cervical	7	7	7
Thoracic	11	13?	13?
Lumbodorsal	24	9	10
Pygal caudals	7	5	6
Diapophysial caudals	25	15	25
Non-diapophysial caudals	45	?	55

The zygapophyses in all three forms terminate at or near the end of the rib-bearing vertebræ. In the cervical region they are strong, diminishing but little in size through the thoracic region. In the region which I call lumbodorsal they become weaker. The vertebræ increase in length through the thoracic region, but diminish very rapidly in length at the end of the costiferous series.

The length of Clidastes velox is about twelve feet, that of Platecarpus coryphæus nearly fourteen, while Tylosaurus proriger, one of the smaller species of the genus, was over twenty-three feet. The smallest species of Clidastes, C. pumilus, if it be a distinct species, was about six feet in life. The largest species of the Kansas Mosasaurs, Tylosaurus dyspelor, had a length of nearly thirty feet. Only one other species of the group larger than Tylosaurus dyspelor has been described from America—Mosasaurus maximus Marsh, from New Jersey. If it had the same proportions as Tylosaurus, its length would be about thirty-two feet. If like Clidastes, as it was in all probability, its length would not exceed thirty-six feet. European forms somewhat larger than this have been described, possibly reaching a length of nearly forty feet. The textbooks and popular descriptions place the length of these animals at from seventy-five to one hundred feet.

The food of the Mosasaurs must have consisted chiefly of fishes of moderate size, with occasional victims of their own kind. While the flexibility and loose union of the jaws undoubtedly permitted animals of considerable size to be swallowed, the structure of the thoracic girdle would not have permitted any such feats of deglutition as the python and boa are capable of. The animals must have been practically helpless on land. They were not sufficiently serpentine to move about without the aid of the limbs, and these were not at all fitted for land locomotion. They lived in the open sea, often remote from the shores. Their pugnacity is amply indicated by the many scars and injuries they received, probably from others of their own kind.—Kansas University Quarterly.

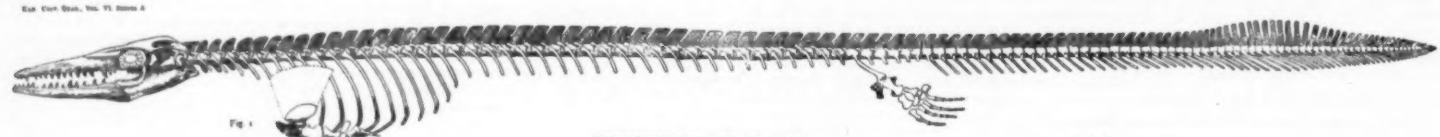


Fig. 1. CLIDASTES VELOX Marsh. One-sixth natural size.

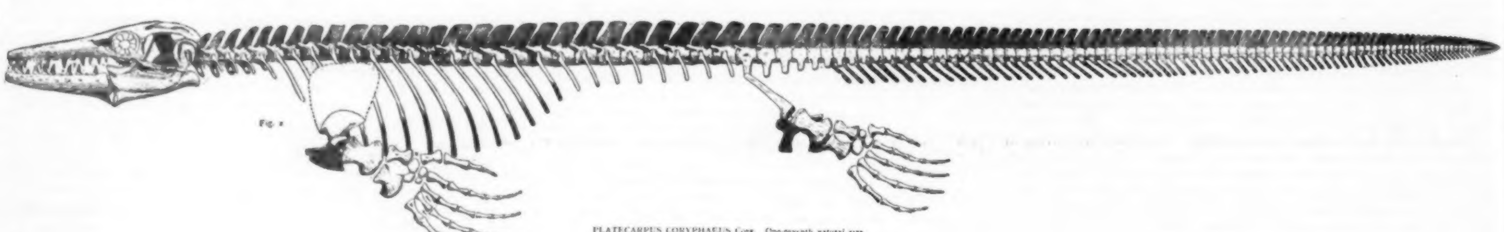


Fig. 2. PLATECARPUS CORYPHAEUS Cope. One-seventh natural size.

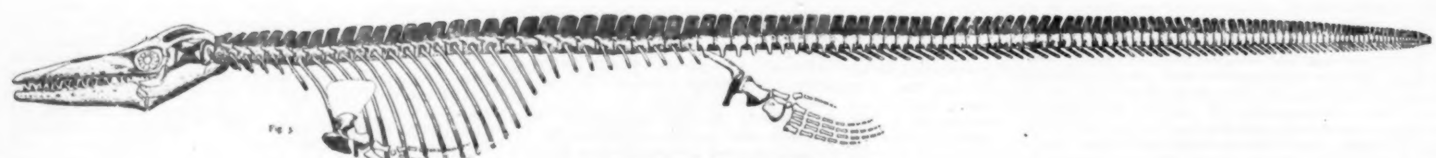


Fig. 3. TYLOSAURUS PRORIGER Cope. One-twelfth natural size.

RESTORATION OF KANSAS MOSASAURS.

MUMMIED HEADS.

HEREWITH are presented four cuts of very strange, post-mortem, artificially contracted Indian heads from Ecuador and Brazil. All have had the bones removed and are mummied to about the size of a large orange; are of slightly aromatic odor and leathery consistency.

The origin of these is somewhat mysterious. They are decidedly scarce, the few that have found their way into museums having for the most part been obtained in or about the town of Macas, at the foot of the

FIG. 1.

Andes—a town which does not at present have any direct intercourse with whites. Those from Macas appear to be larger than the few that have been derived direct from the Indians of the Jivaro tribe.

In the London Intellectual Observer of 1862 Bollaert, who draws his information from a history given by Velasco, says: "Heads of victims are cut off, the skull and its contents removed, and a heated stone introduced into the hollow of the skin. Desiccation goes on and it is reduced to about one-fourth, retaining some few of the features. . . . A double string is attached to the top of the head, so that it may be worn around the neck. The lips are sewn together and a number of strings hung from them, the use of which is not apparent."

In the Journal of the Anthropological Institute for 1874 Sir John Lubbock made the declaration—though upon what authority is not known—that "these heads are boiled for some time in an infusion of herbs, the bones then removed from the neck and heated stones put into the hollow, whereby the head is dried and contracted."

Dr. Page in a recent paper* states, on the strength

FIG. 2.

of "a distinguished anatomical authority in England," that if a dried preserved head be softened, boiled in water, and the bones removed by means of an incision along the occiput, the soft parts will shrink in exactly the same manner as the preserved Indian heads.

The same gentleman gives a list of such heads as he has been able to trace in the different museums of Europe. Besides six that were variously exhibited in London between 1853 and 1882, there are four in the British Museum; one in Brighton Museum; one at Owens' College, Manchester; three at Cambridge University; one in the Antiquarian Museum, Edinburgh; one in the Edinburgh University Anatomical Museum; one in Dublin University; three in Berlin University; three in the Public Museum of Vienna; three in the Vienna Pathological Museum. The editor of this journal has seen no less than four within the limits of the United States and one in Canada, all in private hands, though it is understood one of these has been donated to the Smithsonian Institution. Some of the heads described by Page do not, however, properly belong to this category, as they are of materially larger size, many containing a considerable proportion of the bony constituents, and the majority lack the thread ornaments which are the characteristics of those obtained from the Jivaros. It must be understood at once that the preserved heads from the East Indies, such as

FIG. 3.

are found among the Dyaks of Borneo and Sumatra, and likewise those derived from the Manchurucus of Brazil, are of entirely different character from these herein illustrated, and in great part retain their natural size.

Besides the list given by Page, we are informed there are several in Italian museums—four or five—and three at Madrid; there was also one—that probably pertains to the list given by Dr. Page—in possession of the late Dr. Frank Buckland, a facsimile of which appears in Fig. 1.

Of those brought to the United States, four were originally in the possession of Mr. Hassaurek, formerly United States minister to Ecuador, which the writer had the privilege of examining some years since. Mr. Hassaurek is authority for the information that these are not "worn about the neck," neither are they, as has been generally surmised, worshiped as household gods, but obtained by the Jivaros from the huacas or ancient burial places. While they are regarded with considerable reverence, no such superstition attaches thereto as has been commonly credited. It was a Dr. Andrade, curate of the village of Machuchi, who first propounded the idea that these heads were treated as idols, especially implored to keep family secrets, and for every secret intrusted a string drawn through the lips; he is to be credited also with promulgating the belief that they are worn by their possessors on solemn occasions as ornaments. All this is purely hypothetical, without any true foundation.

FIG. 4.

None of the heads seen by us have ever been opened upon the occiput, and only in one or two instances was there a cord through the sinciput for purposes of suspension.

It would seem highly probable that the threads that passed through the lips originally possessed some such significance as the Quippus of the ancient Peruvians, which are said to have been composed of large base cords, to which were fastened in a peculiar manner threads more or less fine and knotted or entwined in established order for the purpose of expressing ideas, events or numbers. The ancient Peruvians were in the habit of carving in semblance of human form the posts or wooden "idols" (?) which held these registers. The art or science of the Quippu language appears to have been lost to a great extent by modern Peruvians, although it is imagined there are in the southern provinces Indians who understand how to decipher these intricate memorials, but guard their knowledge religiously as a sacred secret inherited from their ancestors.

The configuration of the lips of these mummied heads, the perforations through them—which no doubt date from the earliest history of mummification—strongly suggests a purpose of chronicling history. Something of the same kind was observed of certain of the mummies that have been found of an extinct race that formerly inhabited the Fortunate (Canary) Islands.—The Medical Age.

* Journal of Anatomy and Physiology, January, 1897.

ASTRONOMICAL WORK AT LICK OBSERVATORY.

By EDWARD S. HOLDEN, Director of Lick Observatory.

WHILE the resources of the Lick Observatory are large in comparison with those of many college observatories, they are very small in relation to those of the great establishments of Greenwich, Paris, Pulkova, Washington and Harvard College. For instance, the whole available income of the Lick Observatory for the coming fiscal year (exclusive of salaries) is $5,145. This sum must keep all the buildings painted and in repair; keep all our reservoirs and some five miles of underground pipes in order; provide for all painting, plumbing, brick laying, pipe fitting, carpenter work, machine work, etc., in the observatory and in the houses of astronomers and workmen; buy all supplies, such as lumber, hay, iron, brick, etc.; pay for all instrument making not done in the observatory; pay all freight, express and telegraph bills; maintain a telephone line 17 miles long in good order; pay for fuel; purchase books for the library; provide any needed apparatus for all the instruments; and, this year, buy much of the material needed for an eclipse expedition to India. It is no small task to make the small income cover the requirements. Every want which is felt in a large city is felt here. The circumstances at Mount Hamilton are as different as possible from those at Eastern observatories. There each person must provide for his own personal comfort; here the comfort of each one must be secured by the expenditure of the annual appropriation. If it is insufficient, every person suffers in some degree.

The astronomical efficiency of the Lick Observatory cannot be properly estimated without taking such material and social considerations into account. Under the circumstances, I do not think it is too much to claim that its efficiency during the nine years of its life has been satisfactory. This has only been attained by good will and earnest effort on the part of all concerned—regents, astronomers, mechanics, workmen. The summary of work for which you asked is given below.

Double stars have been measured here in past years in great numbers by Prof. Burnham, and at the present time Profs. Schaeberle, Hussey and Aitken are engaged in such work for parts of their time.

The satellites of Mars, Jupiter, Uranus and Neptune have been regularly observed here for the past nine years by Messrs. Schaeberle, Barnard, Campbell and Hussey. A fifth satellite of Jupiter was discovered by Prof. Barnard in 1892.

The planets, especially Mars, Jupiter, Saturn (and also Venus and Uranus), have been systematically observed for their physical features at every opposition by Messrs. Holden, Schaeberle, Keeler, Barnard and Hussey. For several oppositions of Mars the planet has been followed by Messrs. Holden, Schaeberle and Campbell during every available hour.

Comets have been discovered here in great numbers. Ten comets (seven unexpected) were discovered by Prof. Barnard from 1888 to 1892; five (four unexpected) by Mr. Perrine from 1895 to date. The long series of observations of these and other comets by Messrs. Barnard, Campbell, Hussey, Perrine and Aitken are a contribution to science even more important than the discoveries themselves.

Comet orbits have been computed here by Messrs. Schaeberle, Campbell, Hussey, Perrine and Aitken; and all comets discovered at the observatory have had their first orbits calculated by officers of the university. In this work Prof. Leuschner, of Berkeley, a former student here, and his assistant, Mr. F. H. Seares, have rendered assistance which is much appreciated.

Meteors have been observed and photographed here (and elsewhere) by all the astronomers, and their orbits calculated by Messrs. Holden and Schaeberle.

Double star orbits have also been computed by Prof. Schaeberle.

The zodiacal light was regularly observed (visually) by Prof. Barnard.

The aurora has been regularly observed (spectroscopically) by Prof. Campbell.

Typical or remarkable cloud forms are regularly photographed by Mr. Pauli, janitor of the observatory.

Nebulæ have been observed (visually, photographically and spectroscopically) by Messrs. Holden, Burnham, Schaeberle, Barnard and Campbell.

Star maps have been made and published by Mr. Tucker.

Photometry (photographic and visual)—of eclipses and of stars—has been attended to by Messrs. Holden, Schaeberle, Campbell and Leuschner.

Solar Eclipses.—Those of January and December, 1889, April, 1893, August, 1896, have been observed by Messrs. Burnham, Schaeberle, Keeler, Barnard, Leuschner and Campbell, and the latter will observe the eclipse of January, 1898, in India.

Lunar Eclipses.—All lunar eclipses visible here have been observed.

Occultations.—A series of occultations has been observed here by Prof. Leuschner.

Transits of Mercury.—Three transits of Mercury have been observed, either visually or photographically.

Transit of Venus.—That of 1882 was successfully photographed here by Prof. Todd.

Catalogues of Stars.—Two such are in progress of preparation.

1. A catalogue of double stars and of coast survey stars from observations by Prof. Schaeberle has been (partly) reduced, on lines laid down by myself, by Messrs. Schaeberle, Campbell, Leuschner, Aitken and Prof. Bigelow and Mrs. Updegraff. Prof. Aitken has spent more than a year on this work.

2. A catalogue of 38,000 stars from Washington observations is well toward completion. The reductions have been made chiefly by Messrs. Holden and Aitken. The original observations as printed were full of errors. The final places will be considerably more precise in declination and somewhat less precise in right ascension than the southern zones of Argelander.

Solar Photography.—Some 1,800 negatives of the sun (taken with the photoheliograph) have been secured by Mr. Perrine, and since April, 1896, some 450 more by Mr. Colton. Excellent experimental solar photographs on a large scale have been made with the 36 in. telescope, and it is hoped to go very much further with this work during the summer of 1897.

Lunar Photography.—A very full series of local negatives has been made with the 36 inch telescope, chiefly by Messrs. Holden and Colton. An atlas on the scale of X feet to the moon's diameter has been prepared from these by Prof. Weinek, at Prague. Enlargements in the telescope have been made by Messrs. Holden, Colton and Perrine, and 5 plates of a moon atlas on the scale of III feet to the moon's diameter have been distributed. Twelve more plates are now in the hands of the engraver and will soon be issued; and about 20 more are ready to be published when the funds are available. The atlas will be complete with about 60 plates. All the work in the dark room was done by Mr. Colton.

Photographs of the Milky Way.—A great number of such pictures has been obtained by Prof. Barnard, who is preparing them for publication.

Photographs of planets, especially of Jupiter, have been regularly made by Messrs. Holden, Schaeberle and Colton.

Photographs of comets have been secured by Messrs. Barnard, Hussey and Colton.

Visual Photometry.—Two fine photometers of Prof. Pickering's design have lately been given to us by Miss Bruce. They will be used by Prof. Aitken, chiefly on double stars at present.

Spectroscopic observations of nebulæ, new stars, comets, stars and planets, have been made by Messrs. Keeler and Campbell. The chief problem of the great telescope is to determine the motion of the solar system by spectroscopic observations. It was first attacked here in 1888, and since that time it has been considered as our most important work. The results now attained by Prof. Campbell are of unexampled precision, and some of them will be published shortly. Many unexpected delays have occurred in this research, which has been under the charge of Messrs. Keeler, Crew and Campbell.

Time signals are sent out daily. Mr. Tucker is in charge of our clocks.

Meridian Circle Observations.—Mr. Tucker has completed a fine series of observations of all stars contained in any of the great ephemerides and not contained in the Berliner Jahrbuch. This work is all ready to print. He has also determined the places of a long list of stars used by Prof. Doolittle to determine the latitude of Lehigh University. The division errors of the 1° spaces of both circles of the instrument have been determined by Mr. Tucker with the assistance of Mr. Aitken.

Meteorological observations (tridaily) have been regularly made. They are now in charge of Prof. Aitken. A summary of all meteorological observations made here from 1888 to 1897 is in course of preparation by Mr. Perrine.

Earthquake observations are obtained on our two seismographs, which are in charge of Mr. Perrine. A complete list of all recorded earthquakes on the Pacific coast from 1769 to 1897 has just been prepared by Prof. Holden.

Publications of the Observatory.—The observatory has already issued three quarto volumes and five octavos, besides several pamphlets and the Moon Atlas. The Smithsonian Institution has lately published an octavo prepared here by Prof. Holden — Mountain Observatories—and will probably print his list of recorded earthquakes, just mentioned. Notices from the Lick Observatory regularly appear in the publications of the Astronomical Society of the Pacific. More than 1,200 contributions to astronomical and other journals have been made by the officers of the observatory since 1888.

Trial of the Crossley Reflector.—This fine instrument, which had done such good work in the hands of Mr. Common, was presented to the Lick Observatory by Mr. Crossley in 1895. It was completely mounted in June, 1896, and given over to Prof. Hussey for trial. The work begun in 1896 is now being prosecuted. Photography in the Newtonian and principal foci will be tried by Prof. Hussey, and Prof. Campbell has a programme of spectroscopic observations to be carried on with the Bruce spectrograph (constructed here) in the principal focus. A powerful driving clock (the Bruce clock) has been made here from drawings by Prof. Hussey. It is essentially a copy, in little, of the Warner & Swasey clock of the 36 inch equatorial. Its conical pendulum weighs about 56 pounds.

The Schaeberle 18 inch reflector has been used for some years past in experiments in celestial photography by its maker, Prof. Schaeberle. Very interesting photographs of Jupiter have been obtained.

The Crocker photographic telescopes (a pair of Willard portrait lenses) will soon be mounted in a new dome near the Crossley reflector. A 12 inch mirror (by Prof. Schaeberle) of very short focus is to be mounted on the same stand.

Lick Observatory, July 7, 1897.

CHEMISTRY AND ARCHÆOLOGY.

The fact that all the sciences are intimately allied, and that any one of them may be called upon to serve as the handmaid of any other, is once more exemplified by the services recently rendered to archæological research in France by some analyses made by the eminent chemist M. Berthelot, and described by him in the Comptes Rendus of the Academy of Sciences. By analyzing the metal of some early implements recently unearthed in Chaldea, he shows that they are pure copper—not bronze, as had been supposed—and throws interesting light on the methods and processes of metallurgy in those early times. The Literary Digest translates as follows:

"The discoveries made in Chaldea, at Tello, several years ago, by M. de Sarzec have made known to us monuments of great antiquity, going back to the origins of civilization, that is to say, five or six thousand years. They have furnished, among other things, arms, ornaments and utensils capable of throwing new light on the origin of the metal industries. Such are the objects deposited in the Louvre Museum, which M. Henzey, my colleague, has submitted for my examination.

"I present herewith the results that I have obtained, which form a part of a methodical series of researches that I have been making for several years on the metals of ancient civilizations. The result has been a distinct advance in our knowledge of these interesting questions. In fact, we have here the earliest and most ancient records belonging to the copper age, whose date is definitely known."

The detailed results of a chemical analysis of various objects found in Chaldea are next given, and it is proved that such objects are practically pure copper, although many of them are labeled "bronze" in the museums. Says M. Berthelot:

"The existence of successive stages in the use and purification of metals, whether common or precious, follows from all these analyses. In particular, the employment of pure copper for making arms and utensils, even of current use, in Chaldea, about 4000 B. C., is established by the analyses. It preceded the use of bronze, that is of copper alloyed with tin, which is found in later objects, in Chaldea as in Egypt. We may even add that the form of doweled axes and the processes of manufacture, as well as the practical uses for which these utensils were destined, were the same for the pure copper axes of Chaldea as for the prehistoric bronze axes of Europe and Siberia. These observations appear to me the more worthy of interest, in that they are made on authentic objects that date in Chaldea and in Egypt from times that may properly be called historical—conditions not satisfied in the same degree by pure copper objects found in Europe. The discoveries made in Egypt and in Chaldea cast new light on problems that relate to the origin of metal industry in the history of the human race."

THE PATENT SYSTEM AS A FACTOR IN NATIONAL DEVELOPMENT.*

By William C. Dodge.

The question is sometimes asked: Is a patent system of benefit to a country? and not infrequently we find men and papers advocating the abolition of patents. Those who entertain such ideas generally belong to one of two classes—persons who confound modern patents with the "odious monopolies" of former times, and who think that inventions would be secured just as well without patents, and those who think that labor saving machines deprive men of employment, and are therefore injurious to the laboring classes.

This opposition has exhibited itself from the beginning down even to the present day. It is but a few years since a writer in a paper published at the capital of the United States asserted that "the invention of the steam engine and the sewing machine were among the greatest evils that ever befell mankind;" and it is a matter of history that in the same enlightened land prayers were offered in some of the churches that the wickedness of the newly invented sewing machine might be made apparent, and it makers be struck with a conviction that would induce them to stop its manufacture!

More recently an organ of a labor organization insisted that the introduction of patented machinery worked injury to skilled labor, as have also the leaders of some of these organizations, and writers in periodicals, during the past year.

It is to correct these erroneous impressions that I present the following facts.

If those who confound modern patents with the "odious monopolies" granted by the monarchs would but consider for a moment, they would see how erroneous such an idea is.

Under the old system of "monopolies," rights of which the public were already in full possession were arbitrarily taken from the public and conferred upon individuals, greatly to the injury of the public. For instance, Queen Elizabeth bestowed upon her favorites the exclusive right to sell steel, salt and other articles in the kingdom, the price of salt by the monopoly being increased from sixteen pence to fifteen shillings—over eleven hundred per cent.

On the contrary, a patent, instead of taking from the public anything which it already has, induces the inventor to spend his time, labor and money, and exercise his genius, in devising and giving to the public something new—something which it wants, and which, but for his invention, it might never have had. True, it gives him the exclusive right to make, sell, or use the invention, but only for a brief period, and that only upon the condition that he shall so illustrate and describe it that the public can make and use it at the expiration of his limited right, and thereafter have it free forever.

The difference between a modern patent and an old time monopoly is as clear and as distinct as the difference between day and night, and there is no excuse for their being confounded by any intelligent person. In fact, it was to abolish and prohibit the "odious monopolies" that the patent system was established.

In no part of the world have inventions been so extensively made and used as in the United States, and there can be no better way of determining whether the patent system has been beneficial, and whether or not it is for the public good to continue it, than to consider what it has done for that country.

To get an idea of what has been accomplished during the first century of American existence under the patent system, let us briefly compare the condition of the United States in 1790 with that of 1896.

Their territorial area has increased from 830,000 square miles to 3,314,220; their population from 4,000,000 to more than 70,000,000; their 75 post offices to about 70,000; and their 1,500 miles of postal routes to nearly 500,000 miles, on which there is a travel of 409,388,425 miles—enough to encircle the globe more than 16,000 times! In 1790 they had practically no manufactures. At the close of the revolution their manufactures amounted to only \$20,000,000, the total product as late as 1830 being but \$80,000,000; while in 1890 their manufactured products amount to almost \$9,250,000,000—far more than those of Great Britain, and more than one-third of the total manufactured products of the world. At the same time their agricultural products have grown to the sum of \$4,500,000,000 per annum.

In 1790 such things as steamboats, railroads, telegraphs, and telephones were unknown, while now the United States have 181,000 miles of railroad, with a total trackage of 221,000 miles, giving employment to about 800,000 persons.

The street and suburban railways aggregate nearly 40,000 miles, of which nearly one-third are electric roads, with 30,000 motor cars.

On the 15,000 miles of Western navigable rivers and 95,000 square miles of lake surface there are 2,705 steamers, with a tonnage of 806,584 tons, while the craft on these inland waters number 10,237, with a tonnage of 4,319,734 tons. The traffic on the great lakes alone amounts to nearly 40,000,000 tons. During the eight months of navigation 60,000 vessels pass through the Detroit River, with a tonnage of over 36,000,000 tons. The tonnage of entrance and clearance of the two ports of Chicago and Buffalo exceeds that of any city in the world, except London, and very nearly equals that (London, 20,962,534; Chicago, 10,288,868; Buffalo, 9,560,590). From the single port of Escanaba, on Lake Michigan—a place so young as to be unknown abroad, and known to but few at home—there were shipped in 1892 nearly 4,000,000 tons of iron ore and 120,000,000 feet of lumber, her tonnage being more than half of that of Liverpool, which is excelled only by that of London.

The United States produce now more iron ore and manufacture more iron and steel than Great Britain, which heretofore has led the world in that line. They have 839,905 miles of telegraph wires, with 25,000 stations, independent of ocean cables, and 440,750 miles of telephone wires, with more than 500,000 instruments in use.

But, wonderful as these statistics show the growth of the country to have been, they do not tell the whole story; for it must be borne in mind that in 1790 the four millions of people were scattered mostly along the Atlantic seaboard in sparse settlements. Moreover, it must be remembered that this small number of settlers had the whole continent to subdue—forests to clear, farms to open, houses, roads, bridges, schools, and churches to build, in fact, everything to create, with the savages to contest every foot of advance—and that the western continent had neither the accumulated wealth nor the surplus labor of the old world with which to accomplish this gigantic task. But even that is not all, for, in order to get a clear idea of the conditions under which the United States began existence as a nation, one must consider also the restrictions placed upon the colonists by the mother country.

The policy of the mother country from the very first was one of suppression of all manufacturing industries. As early as 1621 an order of the king and council prohibited the shipment of tobacco or any other production of the colonies to any foreign port, except to be first landed in England, and a duty paid on it there.

This policy was continued even after American independence, and various acts, from 1781 to 1796, were passed, prohibiting under heavy penalties the shipment from Great Britain of "any machine, tool, engine, press, paper, utensil, or any part thereof, or any model or plan thereof, which was, or thereafter might be, used in the manufacture of woolen, cotton, linen, or silk manufactures," and also prohibiting the shipment or enticing away of any artificer or workman in these several branches; and in 1795 this act was made perpetual.

It was not until 1825 that the restriction upon workmen leaving the country was repealed, and that upon machinery not until 1845.

The object of all this, as stated in the preamble to the act of 1763, was "the keeping of his majesty's subjects in the colonies in a firmer dependence," "the increase of English shipping," and "the vent of English manufactures." The idea and purpose of the British government in reference to the colonies was succinctly stated by Sir Robert Peel, when he said: "It is the destiny of the United States to feed Great Britain, and the destiny of Great Britain to clothe the United States."

Of course, under such control by the mother country, the colonists could engage in nothing but farming and the production of raw material, to be shipped to England for the use of her manufacturers.

During the revolution manufactures were established to partly supply home needs, but with the close of the war a reaction set in that soon destroyed most of them. Under the confederation of the colonies, which was solely for common defense, the general government had no power to grant patents, or to regulate commerce, or to impose duties on foreign goods, those rights being exercised by each colony or State as it saw fit. Massachusetts, New York, and those most interested in commerce, imposed no duties, and the result was that, in a year or two after the close of the revolution, the country was so flooded with the cheap products of England and other countries as to break down all the manufactures that had been established during the revolution and bankrupt the merchants. So terrible was the condition of affairs that petitions were sent to Congress asking it to issue "flat" paper money, and loan it to the people. In Pennsylvania the State government actually did this.

It was this condition of affairs which finally resulted in the constitutional convention in 1787, which conferred on Congress the powers under which the country has since grown to its present estate. Among the powers conferred on Congress by the Constitution, two of the most important, so far as national prosperity and growth are concerned, are the power to regulate commerce and impose duties on imports and the power to provide for the grant of patents. These may well be termed the right and left arms of American growth

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and prosperity, and it is a question which, after all, is the right arm and which the left. Under the exercise of those two powers, for the first century of existence, the United States have so grown and prospered that they now do one-third of the world's manufacturing, one-third of its mining, and one-fifth of its farming, and possess one-fifth of its wealth. And, best of all, this is the result of peace and the intelligent application of the arts.

Now, what has caused this marvelous growth? Doubtless there are several causes. The cheapness of a virgin soil and free institutions inducing immigration from abroad were two of the causes; but those alone do not account for it.

By some it is contended that the tariff has been the prime cause of American prosperity. Without desiring to discuss that or any political question, and admitting that a tariff is necessary for national revenue, and that it has been, and is, of importance to the manufacturing interests of the country, I assert, without fear of successful contradiction, that the patent system of the United States has been, and is now more than ever, one of the prime causes of national growth and prosperity.

As stated by Commissioner Leggett in his report for 1878, from three-fourths to nine-tenths of all American manufacturing is based, directly or indirectly, on patents; that is to say, the people are engaged in manufacturing patented articles, or are using patented machines and processes to manufacture articles not patented.

One need but step into any shop where articles are being produced—from the saw mill in the woods that now cuts its 300,000 feet per day to the little shop in the attic where toys are produced, or the great factories turning out their millions' worth of articles of every variety—to prove the truth of this statement. In fact, you cannot touch a thing anywhere, in the shop, on the farm, in the household, or the office, that does not bear the impress of patented inventions.

But to show that this is not merely an individual opinion, let me quote what an intelligent Englishman says on the subject. Harris Gastrell, secretary of the British Legation, in a detailed report a few years since to his government upon the industries of the United States, says:

"I cannot close this report without recording the fact that, in every important branch of industry referred to in the course of the previous pages, the American manufacturers seemed to be ever gaining on their competitors of the old world by availing themselves to the utmost of every advantage of improved process or labor saving machinery which American or other inventors may offer.

"There can be little doubt but the celerity with which all such advantages are thought out and then introduced into general use is owing to the constant pressure of high rates of wages and the comparative certain protection of capital invested in inventions.

"Neither can I close without observing how favorably the great industries of the United States would probably compare with the best organized of the competing industries of Europe. The past history and present development of the textile (and metal) industries is an earnest of a prolific future. Whether or not a reduced cost of living shall ever be attained, I cannot doubt that, under sound conditions of production, American industry will not only supply its own market, but will also become a formidable competitor in foreign markets in many articles.

"How soon that competition abroad may take place in this or that industry is not for me to conjecture. But I think that the data in this report are sufficiently full and correct to enable others to predict that time in respect to the cotton and woolen industries."

At a meeting of the British Association, after his return from the Philadelphia Centennial Fair, Sir William Thomson said:

"I was much struck with the prevalence of patented inventions at the exhibition; it seemed to me that every good thing deserving a patent was patented. I asked one inventor of a very good invention: 'Why don't you patent it in England?' He answered: 'The conditions are too onerous.' We are certainly far behind America's wisdom in this respect. If Europe does not amend its patent laws, America will speedily become the nursery of inventions for the world."

Mr. Hulse, the English judge of textiles, in his report to Parliament, said:

"The extraordinary extent of ingenuity and invention existing in the United States and manifested throughout the Exposition I attribute to the natural aptitude of the people, fostered and stimulated by an admirable patent law system."

So, too, the Swiss commission were so impressed by what they saw at Philadelphia that they published an address to their manufacturers, in which they told them that their only hope was in the adoption of a patent system; and the result was that Switzerland in 1888 adopted a patent law.

The United States consuls, in their reports to the State Department on the effect in Europe of the Centennial Exhibition in 1876, show how American implements and products were being preferred in Europe, especially agricultural machines and tools; and Consul Winser gives long extracts from a book published by Dr. Herman Grothe, a prominent German political economist, who visited the fair for the sole purpose of "studying the principles which had operated so powerfully in bringing about this rapid and high development of American industries," and who lays great stress on "the stimulating effect of the patent laws."

Dr. Grothe further says:

"Moreover, owing to the use of labor saving machinery and finer and better adapted tools, the cost of manufacture, in spite of higher wages in the United States, is lessened to the point where competition with other nations in supplying foreign markets may fairly be tried; and there can be no doubt that a great many lines of American wares will eventually find ready sale in the German market, in some cases to the exclusion of the same classes of goods of English, French and even home manufacture. All this is granted."

In the reports of the British commissioners to Parliament it was stated that, "as regards extent of invention and ingenuity, the United States was far ahead of other nations;" that "a great part of the marked advance in the improvement of workmen's tools which has been made during recent years is justly due to the inventive genius of American citizens;" that "one cannot fail to notice the great fertility of invention displayed in America;" that "there is great inventive power, and a ready and fearless adaptation of the means to the end sought;" that "no one could fail to be struck with the great and successful application of science to useful purposes in America;" and that, "judged by its results in benefiting the public, both by stimulating inventors and by giving a perseveringly practical turn to their labors, the American patent law must be admitted to be the most successful, and the beneficence of its working was very amply illustrated throughout the American region of the Exhibition."

Edward Bally, one of the Swiss commissioners, said: "I am satisfied from my knowledge that no people have made, in so short a time, so many useful inventions as the Americans; and if to-day machinery apparently does all the work, it nevertheless by no means reduces the workman to a machine. He uses a machine, it is true, but he is always thinking about some improvement to introduce into it, and often his thoughts lead to fine inventions or useful improvements."

As a result of these obvious facts, a committee of the British Parliament some years ago, after two years of investigation, recommended the adoption of the American patent system, and again in 1894 the subject was agitated. Norway and Sweden in 1885, Canada in 1886, and Germany in 1888 adopted a similar system of preliminary examination, and now they grant patents only for what is new and original. Thus the foremost manufacturing nations of Europe recognize the superiority of the American patent system, and make acknowledgment of its beneficial results.

Now, when the United States manufacture more than they consume and seek other markets for a surplus of both manufactured and agricultural products, the patent system more than ever becomes important; for, with higher priced labor and raw material, how are goods to be made there, and sold in Central and South America, in open competition with the cheaper labor and cheaper raw material of England, France, Belgium and Germany? If the cost of both labor and material could be reduced to a European basis, then, of course, America could compete; but that can not be done, for the price of labor cannot be fixed by law, nor would the United States want to reduce it, if it could. That was tried in England, and also in New England, and abandoned centuries ago.

The main hope is in inventions and the skill and energy of the American people. If inventors can furnish manufacturers with improved machines and processes, which will reduce the cost of production from fifteen to twenty per cent., then the new world can compete with the old world; otherwise not. Already that point is rapidly approaching, as the following facts show:

In 1830 the manufactured products of the United States amounted to but.......	$80,848,210
By the census of 1850 they had grown to..	1,019,109,616
" " 1860 " " " ..	1,885,861,676
" " 1870 " " " ..	3,385,860,354
" " 1880 " " " ..	5,369,579,191
" " 1890 " " " ..	9,224,541,094

Or, according to Mulhall, more than one-third of the total manufactured products of the world!

This remarkable increase has been largely, if not mainly, due to inventions, stimulated and fostered by the patent system. As proof of this I cite the fact that the amount per hand employed has constantly increased. For instance, as shown by the census reports, in 1850 the product per hand, yearly, was $1,564, while in 1890 it had grown to $2,250—an increase of nearly 44 per cent. in forty years. During that time the hours of labor have been reduced at least 20 per cent., and yet the product per hand has increased, as above shown. Nor is this all, for, while the hours have been decreased, and the product increased, the wages paid those hands have increased in even greater ratio, or from an average of $247 per year in 1850 to $450 in 1890, an increase which is even further augmented if measured by the purchasing power of a dollar then and now.

Now, how is it, and what is it, that enables an operative to-day to produce so much more, in a less number of hours, than he could thirty or forty years ago? It is simply invention, as embodied in the improved machines, tools, processes and appliances that American inventors are constantly furnishing to American manufacturers.

Near Baltimore there was recently erected one of the largest plants for the manufacture of Bessemer steel in all its forms in the world; and, as recently stated by its superintendent, by means of the inventions and improved appliances they have adopted they are enabled to produce a ton of steel with but one-third of the manual labor required at their other establishment, built twenty or twenty-five years before.

In 1866 steel rails cost $165 per ton. In 1884 they had dropped to $34, in 1893 they were $21 to $24 per ton, and in 1897 even less. See how that has expedited the building of railroads, which now cover the country like a network, and without which modern existence could not be carried on. And the same is true of steel in all its forms, so that to-day we build steel bridges, steel vessels, steel cannon, steel frames for our buildings, and for farm implements, and use steel nails.

Inventions and improvements have so reduced the cost of steel rails that already, during the year 1897, the United States have sold 100,000 tons to Europe. They sold 100,000 tons of pig iron from the Southern States in 1896, and this year it is estimated that it will be 250,000 tons, where before the war none was produced. In 1896 the American export of iron and steel, manufactured and unmanufactured, amounted to over $41,000,000.

As an illustration of the benefits of invention, take the common nail. In 1818, when they began to be made by a machine operated by hand in Pennsylvania, they cost from 10 to 37½ cents per pound, according to size. Now they are sold at 1 to 1½ cents per pound—so cheaply indeed that a carpenter, working for 30 cents an hour, had better let a nail go than to spend ten seconds to pick it up, for ten seconds of his time is worth more than the nail!

In a report made by the United States consul at Birmingham, he cites a paper prepared by an English expert, who forcibly describes the danger from American competition to the British manufacturer of steel.

That is the result of invention. And the same is true of nearly all branches of manufactures. Says the Iron Industry Gazette:

"Disparagement of patents is common and easy, but it should not be forgotten by those who sneer at inventors that, out of a total of over $8,000,000,000 of capital invested in manufacturing in the United States, patents form the basis for the investment of about $6,000,000,000. Evidently, the United States system of encouraging invention that has resulted in the patenting of over 500,000 inventions is a system that is exceedingly wise and valuable. The one thing that has enabled manufacturers to make so wonderful a progress in the United States is its patent system."

PHYSIOLOGICAL EFFECTS OF MENTAL WORK.*

WITHIN the present decade the relation between mental work and the bodily processes has been the subject of much study. Interest in the problem as a field for practical inquiry was first aroused by a paper on the fatigue resulting from intellectual work, published by Sikorsky in the Annales d'Hygiène Publique for 1879. He was followed more than ten years later by Burgerstein, Laser, Griesbach and others. In these investigations the method used was that of testing school children in classes. Various problems and exercises were set before them, during and after the school session, and the percentage of errors committed in the operations was taken as measure of the fatigue due to mental work. While some individual errors might be due to other causes, the average percentage of the entire class seemed a fair test of this factor. The latest instances of this method are the investigations of Friedrich and Ebbinghaus, described in the May number of the Naturalist. At about the same time Mosso and his pupils took up the question from another side. They instituted a series of laboratory investigations upon single individuals by means of the ergograph, with a view to determining the fatigue due to steady intellectual as well as physical work. Kraepelin and his pupils meanwhile undertook the same problem, varying it with tests of the influence of various stimulants and narcotics on the capacity for mental work. They made use of the reaction time method, as well as the percentage of errors. More recently, Binet and his pupils have taken up the subject from a different standpoint, their object being to measure the effect of mental stimulation and mental effort on the bodily processes of breathing, heart action, etc. Several other investigators have studied the problem in one or other of these forms. Among them may be noted Féré, Patrick and Gilbert, Frey, Bolton, Bergström and Henri.

In an article in the Année Psychologique for 1896, M. Henri gives a résumé of the various investigations and the methods used in each. He emphasizes the importance of distinguishing the different factors involved in both mental and physical work, and of studying each one separately by appropriate experimental methods. Among these factors he specifies in particular attention, voluntary effort, the psychic processes of memory and imagination. Little progress has as yet been made in the way of investigating effort, except in the study of pathological cases, such as aboulia. As for attention, while considerable work has been done in this field, the investigations have generally had for their end to determine the mental effects of fatigue and other variations in the conditions, rather than to measure the physical effects of variations in the attention. Memory has been, perhaps, more systematically studied than any of the other factors.

The investigation of the effect of intellectual work on the pulse and other functions which MM. Binet and Courtier have undertaken seems most likely, of all methods so far devised, to furnish a measure of psychical work in physical terms. A series of papers on the subject by these authors has appeared in the Année Psychologique, the first in the issue for 1895 and four others in the last volume.† In approaching the question it was first of all necessary to study the effect of changes in respiration on the heart beat and blood supply. A large part of the first paper is accordingly taken up with this and with an examination of possible errors in the apparatus. The instrument used was the plethysmograph of Hallion and Conte. This consists of a rubber cylinder, which is grasped firmly by the hand. The outer surface of the hand is covered with a tight-fitting glove, so that any expansion in volume of the hand (due to increased blood pressure) takes effect on the inner surface, and results in diminishing the volume of the rubber cylinder. The latter communicates by means of a tube with a flexible drum. When the cylinder is compressed by the hand the drum rises, and the effect is recorded by means of a pen attached to the drum. The apparatus was found to be very serviceable, and was remarkably free from error. In addition to the frequency and strength of the pulse beat, the dicrotism, or break in the beat, was clearly marked in the diagrams, and proved an important factor in the results.

MM. Binet and Courtier note the existence of important individual differences in the effects of mental work on the physical processes. In some subjects these are confined almost wholly to changes in the respiration, in others to the action of the heart, while in others they are felt more especially in the vaso-motor system. In general, the effect on the respiration is to make it more rapid and at the same time more superficial. The effects on the pulse curve most frequently observed are: 1st, diminution of amplitude; 2d, diminution of amplitude with change of form; 3d, diminution of amplitude, change of form and lowering of the level of the curve. One or other of these effects appears in almost all the subjects tested.

In their later papers the authors consider in turn the various causes of change in the pulse. They confirm the well known diurnal changes by numerous observations with their own method, e. g., that the pulse becomes more frequent and the dicrotism generally more marked immediately after a meal. As regards physical exercise, they lay special stress on the changes that occur in the dicrotism according as the exercise is local, general and moderate, or general and fatiguing.

The study of the effects of mental work is, of course, the most important from the psychological standpoint, and here the authors have sought to combine tests of

* The American Naturalist.

† Vol. III, 1896, published this spring.

the heart and respiration with those of the pulse. In addition to the more delicate tests, involving simple mental operations, two of the subjects undertook a piece of severe and prolonged mental work. They spent seven hours working steadily at this task, merely resting at the end of each hour for a time sufficient to perform the necessary tests. Comparing the results with those of a similar period passed under similar conditions but without work, the pulse was found to be considerably retarded in the former case, as compared with the latter, the retardation taking place especially in the early part of the period. The authors sum up their results on mental work as follows: "1. An energetic but short mental effort produces an excitation of function, vaso-constriction, acceleration of the heart and of the respiration, followed by a very slight retarding of these functions; in some of the subjects a blunting of the dicrotism. 2. Intellectual work lasting for several hours, with comparative immobility of the body, produces a retardation of the heart and a diminution of the peripheral capillary circulation."

As regards the relation between physical and mental work, the authors are cautious in drawing conclusions. They observe a certain parallelism, in that a single energetic effort produces an acceleration of the heart and lungs, while a long-continued and fatiguing effort frequently weakens the dicrotism. On the other hand, the excitation of the heart is more marked and the acceleration of the respiration greater in physical than in mental work; again, in physical work the respiration grows deeper, while in mental work it becomes more superficial; and finally, prolonged mental work tends to produce a weakening of the peripheral circulation—an effect not observed in the experiments on physical work.

The effects of emotion on the heart and pulse are the topic of the last paper by the same authors. The experiments on this difficult problem were contrived with considerable ingenuity. Some of the subjects were children of from eight to ten, in whom it was easy to excite fear, surprise, pleasure, etc. With adults the tests had to be more carefully planned. A false alarm of fire was prearranged in one case, and resulted in real fear on the part of the subject. Another subject, after being blindfolded, had his hands placed on a pile of worms. A number of tests embodying various emotions were successfully made. It was found that every emotion tended to weaken the pulse. The quality of the emotion, whether pleasurable or painful, had no marked influence—the contrast was altogether between a state of mental rest and one of emotional disturbance. The heart showed a tendency to accelerate when the excitement was strong, and here too no difference was observable between the pleasant and the painful. The influence on the respiration was most marked of all. Every emotional excitement produced an acceleration and at the same time an increase in depth and a shortening of the pause.

The authors added a special study of the effects of music on these functions. Their experiments on this point were confined to one person—a man of fine musical appreciation and with considerable of a musical education. They represent, therefore, merely a single type of individual. There was found to be a distinct though slight quickening of the respiration and heart in consequence of hearing the tones themselves, and apart from any emotional "echo" aroused by them. When a melody was played, whether sad or gay, the acceleration was more marked, and it reached a climax when the piece was of a dramatic character and particularly fitted to arouse emotion. This acceleration, however, was not accompanied by any noticeable irregularity. There was at the same time in general a weakening of the capillary circulation, which was less when the sounds had merely a sensorial effect than when they produced a distinct emotional disturbance.

In summing up the whole question of emotional effects on the bodily functions, the authors again lay stress on the differences among individuals. From their own observations they are inclined to distinguish three separate classes of effects. 1. In a majority of persons every emotion produces a vascular constriction, an acceleration of the heart and of the respiration, and an increase of amplitude in the thoracic cavity. 2. In some few cases a sensation of pain or an emotion of sorrow may produce a slight retardation of the heart. And 3. It is possible, as observations made on one subject prove, that the form of the capillary pulse may change with the quality of the emotion; this last effect, they remark, may in time enable us to make a classification of the emotions according to their physiological effects on the form of the pulse.

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